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SMITHSONIAN INSTITUTION
UNITED STATES NATIONAL MUSEUM
Bulletin 67

DIRECTIONS FOR COLLECTING AND PRESERVING INSECTS

BY

NATHAN BANKS

In collaboration with various members of the Bureau of Entomology, Department of Agriculture

WASHINGTON
GOVERNMENT PRINTING OFFICE
1909

PAPILIO ASTERIAS—BUTTERFLY, CATERPILLAR, AND CHRYSALIS.

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BULLETIN OF THE UNITED STATES NATIONAL MUSEUM.

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II

ADVERTISEMENT.

The scientific publications of the National Museum consist of two series—the *Bulletin* and the *Proceedings*.

The *Bulletin*, publication of which was begun in 1875, is a series of more or less extensive works intended to illustrate the collections of the U. S. National Museum and, with the exception noted below, is issued separately. These bulletins are monographic in scope and are devoted principally to the discussion of large zoological and botanical groups, faunas and floras, bibliographies of eminent naturalists, reports of expeditions, etc. They are usually of octavo size, although a quarto form, known as the Special Bulletin, has been adopted in a few instances in which a larger page was deemed indispensable.

This work forms No. 67 of the Bulletin series.

Since 1902 the volumes of the series known as "Contributions from the National Herbarium," and containing papers relating to the botanical collections of the Museum, have been published as bulletins.

The *Proceedings*, the first volume of which was issued in 1878, are intended as a medium of publication of brief original papers based on the collections of the National Museum, and setting forth newly acquired facts in biology, anthropology, and geology derived therefrom, or containing descriptions of new forms and revisions of limited groups. A volume is issued annually, or oftener, for distribution to libraries and scientific establishments, and in view of the importance of the more prompt dissemination of new facts a limited edition of each paper is printed in pamphlet form in advance.

RICHARD RATHBUN,
Assisant Secretary, Smithsonian Institution,
In Charge of the United States National Museum.

WASHINGTON, U. S. A., *September 16, 1909.*

INTRODUCTION.

The former work, prepared in 1892 under the direction of the late Dr. C. V. Riley, served a most valuable purpose in showing beginners the best methods of collecting and preserving insects. During the years that have passed since its preparation many new methods have been devised and studies conducted on entirely new lines. Therefore it has been considered necessary to prepare an entirely new paper. Many notes on methods of preparation of material have been culled from the pages of the entomological journals, and several members of the Bureau of Entomology have furnished items of value in their special lines.

Practically every entomologist of much experience has developed methods especially suited to his favorite group of insects, and agreeable to his temperament. One can not expect that his methods will be adopted entirely by others. Therefore in the following pages several methods are usually given for doing a thing, and other ways are doubtless familiar to many collectors. As a general rule patience in collecting, care in the handling, and uniformity in the preparation of specimens will result in a good collection. And a good collection is the first requirement and the greatest inducement to study any group.

NATHAN BANKS.

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DIRECTIONS FOR COLLECTING AND PRESERVING INSECTS.

By Nathan Banks,
Custodian of Arachnida, U. S. National Museum.

CHARACTERISTICS OF INSECTS.

Insects are readily distinguished from similar animals by a number of structures or characters. The body is segmented—that is, composed of a series of rings or segments. They have jointed or articulated appendages, such as legs and feelers, or antennæ. Worms do not have these jointed appendages. Insects possess six of these true legs and one pair of antennæ. Spiders do not have antennæ, but have eight legs. Millipedes and centipedes have more than six legs; and crustacea or crabs also have more than six legs and often two pairs of antennæ. Nearly all insects are winged in the adult form. The other groups are not winged. The insects are known scientifically as Insecta, and, together with the crustacea, spiders, centipedes, and millipedes, they form a group known as Arthropoda. Sometimes the insects are called Hexapoda, or hexapod insects, to distinguish them from centipedes and the spiders. Most insects have the body more or less distinctly divided into three or four parts. The head is always distinct (fig. 1), bearing below the mouth-parts and above the antennæ or feelers and a pair of compound eyes. In many cases there are between the compound eyes two or three simple eyes or ocelli. Behind the head is the thorax, but in the case of beetles and some other insects the prothorax is a distinct main division of the body. The thorax is of three parts—prothorax, mesothorax, and metathorax—each part bearing a pair of jointed

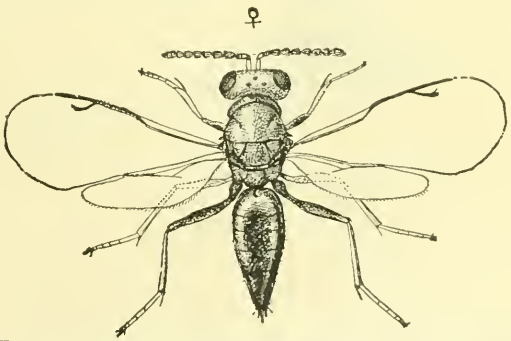

Fig. 1.—Habrocytus thyridopterigis, showing principal parts of an insect.

legs, and the mesothorax and metathorax ordinarily have each a pair of wings. Behind the thorax is the abdomen, bearing at its tip the genitalia, sting, ovipositor, or sometimes jointed setæ or cerci.

Insects are bisexual, there being a male and a female form. In some social insects there are other forms known as workers and soldiers. The female commonly deposits eggs, but in some cases living larvæ. The eggs hatch into larvæ; the larvæ feed, molt, or change their skin several times, and then turn into nymphs or into pupæ. The nymph is active and feeds in a similar manner to the larva, but shows small wing-pads on each side of the thorax, the rudiments of the future wings. From the nymph there issues in time the winged insect. This development through the nymphal stage is called an incomplete metamorphosis. Most insects, however, change from the larva to the pupa, which is quiescent and does not feed, and differs greatly from the larva in appearance (fig. 2). This pupa may be naked, as a chrysalis, or inclosed within a cocoon of silk or earth. From the pupa there issues in due time the winged insect. This line of development is called a complete metamorphosis. These differences above noted are not only external. In the case of a complete metamorphosis, the changes that occur inside of the pupa are often revolutionary in the extreme. The entire internal structure, except the nervous system, may be reduced to a mass of liquid, and the organs of the mature insect developed from this liquid.

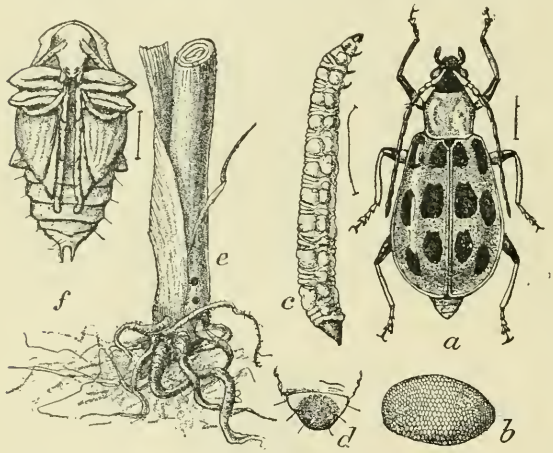

FIG. 2.—DIABROTICA 12-PUNCTATA, SHOWING TRANSFORMATIONS: *a*, BEETLE; *b*, EGG; *c*, LARVA; *d*, END OF LARVA; *e*, WORK OF LARVA; *f*, PUPA.

The wings of the anterior pair in insects are called the forewings or primaries, and the others the hind pair, or secondaries. When the forewings are thickened, they are called tegmina or elytra. The wings have numerous veins through them, the arrangement of which is constant for each species and of great value in classification. This arrangement of these veins is called the venation. The legs are known as front, middle, and hind legs, and each is composed of several parts. The most basal part and attached to the body is the coxa; the next is a minute piece, the trochanter; the third a long

piece, the femur; then the tibia; and beyond that the tarsus. The latter is of from one to five joints, and ends in one or two claws. The top of an insect is called the dorsum, and the lower surface the venter; the sides are the pleura. Insects do not breathe through the mouth, but by means of tiny apertures called spiracles placed along the sides of the body, mostly upon the abdomen. Their mouth-parts, or cibaria, present a great diversity of structure and use. Commonly, in biting insects, there is a pair of hard jaws, or mandibles; below them a pair of maxillæ, bearing a pair of maxillary palpi (short, jointed appendages); and an upper and a lower lip. The latter also bears a pair of palpi, the labial palpi. In many forms there is an unpaired central piece, the tongue or hypostome. In many insects these parts or some of them are modified to form a sucking apparatus. The sight of insects is very different from our own, and most insects apparently do not notice objects a few feet away from them. The sense of smell is very acute, and serves to attract them to their food, to the food plant of the larvæ, or to their mates. It is usually considered that the antennæ bear the organs of smell. Many insects make sounds; therefore they must hear. The organs which effect audition are, however, known only in a few groups and are very different from our ears. Most insects do not live long in the adult or winged stage; some only a few days, comparatively few more than one year. Some, however, spend several years in the larval and nymphal conditions. When once an insect acquires wings it does not increase in size, so that the little flies are not, as is often supposed, the young of the big ones.

IMPORTANCE OF ENTOMOLOGY.

When the early entomologists wrote upon their favorite theme it was customary to apologize for studying such unimportant things as insects, and to justify their actions by quotations from the Bible, or reflections on the insignificance of human life. These remarks of the ancient writers are as pertinent as ever, but, thanks to the more enlightened spirit of this scientific age, are no longer necessary. The losses caused by insects to the crops of the country are beyond the appreciation of man's mind. The cost of the damage by a single species often runs up into millions of dollars. Likewise the importance of the beneficial species which prey on and destroy the injurious forms is now, through such striking examples as the Vedalia ladybird, becoming familiar to all. Beside the two notably useful insects—the honey bee and the silkworm—the lac-insects, cochineal, blister flies, ink galls, etc., are of direct benefit to mankind.

The rôle of insects in the transmission of disease has, in recent years, assumed a tremendous economic importance. The cattle tick was for years the principal exponent of the possibilities along this line, but

now a dozen or more ticks are known to disseminate diseases. One particular mosquito, *Anopheles maculipennis*, is the main factor in malaria, while another species, *Stegomyia calopus*, is equally as responsible for yellow fever. This small family of insects, entirely neglected a few years ago, is now studied by dozens of entomologists. A flea (*Xenopsylla cheopis*) is now connected with the distribution of the bubonic plague. The house fly, that formerly was thought useful in the destruction of decaying matter, is now known, through its deposition of flyspecks on our food, to be concerned in the spread of typhoid fever, and a possible factor in several other diseases. Undoubtedly other insects will be connected with the spread of disease as the field of medical entomology is daily widened in extent and importance. In the Tropics a large number of diseases are distributed by insects. The Nagana disease of South Africa is distributed by the Tsetse fly; the sleeping sickness by a similar species of fly; the Surra of India by horse flies, etc. Indeed, the wild animals of the forests have lost their terrors, and it is the minute creatures that are full of danger.

In the number of species, insects far exceed all other animals taken together. Estimates made by well-known entomologists of the number of insects in the world have ranged all the way from two to ten millions of kinds. More than 35,000 forms of insects are already known from our country and this is probably not half of the entire number. Recently a famous European entomologist, Dr. A. Handlirsch, has figured out that there are about 385,000 species of insects described from the entire globe. Of them 172,500 are beetles; 60,000 moths and butterflies; 55,000 ants, bees, and wasps; 44,000 two-winged flies, and 33,000 true bugs. One single family of the beetles, the weevils, numbers 23,000 species. And, moreover, fully 6,000 species are described as new by entomologists each year.

Aside from their great numbers or their agricultural or their medical importance, insects are a source of study, of interest, of pleasure and recreation to an ever-increasing number of naturalists year after year. The pleasure in securing the many beautiful forms, the interest in studying the remarkable structures, or the charm in unraveling a peculiar life history has attracted many a busy man as a means of relaxation from the ordinary duties of life. It affords a recreation at once healthful and instructive. The increasing interest in outdoor life and in nature study constantly brings insects into prominence as a group easily observable and replete with interest. All of these factors have combined to give insects such importance that there are now in this country over 2,000 members of the brethren of the net.

CLASSIFICATION.

The arrangement of insects in groups is known as "classification." The plan of classification is as follows: Each kind of an insect is called a species; several kinds that are similar to each other form a genus; several genera that have many structures in common make up a family, and families in turn form an order. Between these groups entomologists sometimes place other groups, such as suborder, below the order; superfamily, above the family; subfamily and tribe, below the family; subgenus, below the genus, and variety, race, subspecies for forms of the species.

Each insect has two names, words of Latin or Greek, at least in form, such as *Papilio asterias*. The first name is that of the genus, the second that of the species; in combination they form the scientific name of the insect. The species name is not used twice in the same genus, and the generic name is used only once in the names of animals. If two or more names have been given to the same insect, we use the first one.

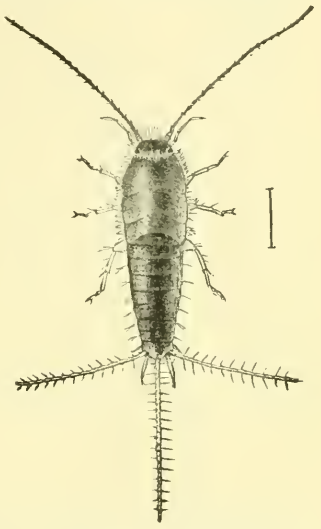

FIG. 3.—ONE OF THE THYSANURA OR FISHMOTHS, LEPISMA SACCHARINA.

There are many classifications. That of Linnæus consisted of seven orders, but most later writers have insisted on several other orders. Some of these orders are perhaps unnecessary for the purpose of the beginner. About fifteen orders will be sufficient to indicate most of the larger natural groups. These are as follows: Thysanura, Collembola, Platyptera, Archiptera, Orthoptera, Hemiptera, Thysanoptera, Neuroptera, Coleoptera, Strepsiptera, Trichoptera, Lepidoptera, Diptera, Siphonaptera, and Hymenoptera.

THYSANURA.

To this order belong certain wingless insects, the more familiar of which are commonly called fishmoths (fig. 3). The fishmoths occur in houses and infest books and wall paper, feeding on the starchy paste. Other forms occur among fallen leaves in the woods, under stones, etc. They are rather slender, tapering, and with long antennæ, and two or three long setæ or tails. The body is soft and covered with scales. They undergo no metamorphosis, and are the most primitive of the insects, similar to the insects from which have developed all the other orders. They have been studied but little by entomologists.

COLLEMBOLA.

These tiny wingless insects are known to every collector as "springtails," on account of their agility in leaping (fig. 4). Their body is divided into two parts—the head, and a larger posterior part bearing the legs, and beneath near the tip is a forked spring. This spring, or furcula, is held in a catch near the base of the venter, and when let loose sends the insect through the air to a comparatively great distance. Nearly all of them occur in damp situations. As with the Thysanura, they pass through no metamorphosis, and many of them are covered with scales. There are a great many species of these tiny forms, and they have been collected by only a few entomologists. Most of them should be mounted upon slides. Some, however, may be kept in small vials of alcohol, with a little glycerin. Springtails may be collected by the use of a toothpick and a vial of glycerin. Touch the toothpick to the glycerin and then bring it close to the insect, which, upon touching the liquid, will become attached, and then may be washed off in a vial of alcohol. Sometimes a small forceps with a drop of liquid between its nearly closed tips is useful in picking up these agile creatures. Many of them will be found when sifting fallen leaves and moss.

FIG. 4.—A SPRINGTAIL, ENTOMOBRYA LANGUINOSA.

PLATYPTERA.

This order includes small, soft-bodied insects, often wingless. The mouth-parts are formed for biting, although rarely very strong. They are never aquatic in any stage, and the young have a great resemblance to the adults. There are three principal suborders, as follows:

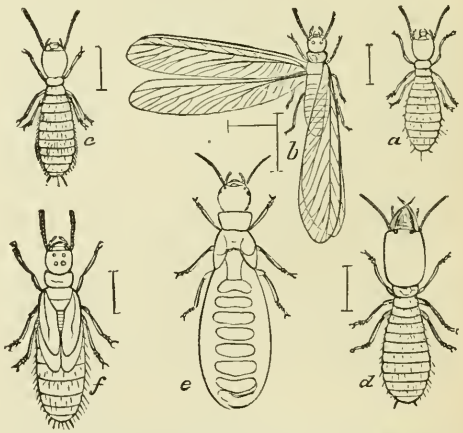

FIG. 5.—A WHITE ANT, TERMES FLAVIPES: *a*, WORKER, *b*, MALE; *c*, *e*, *f*, STAGES OF FEMALE; *d*, SOLDIER.

Isoptera.—To this suborder belong the termites or white ants (Termitidæ) (fig. 5) and a few other allied insects. They are social, living underground in large colonies consisting of several forms of individuals. The queen is the mother of the colony, and after starting a nest she never leaves it. The workers, or neuters, are most numerous and perform all the work. The soldiers are large-headed forms which

guard the colony. The males appear at certain times, and they and the queen are winged. The neuters and soldiers are always wingless. Sometimes they do damage to woodwork and to books. A few of the tropical kinds make enormous nests, sometimes higher than a man; others make nests in trees. The Embiids are similar insects, living in less numerous colonies and spinning a web wherever they go. These forms are best collected in alcohol, though some of the winged termites may be mounted on points.

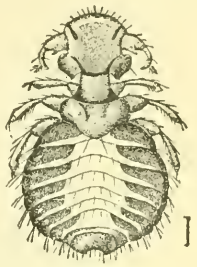

FIG. 6.—ONE OF THE BIRD-LICE, GONIODES FALCICORNIS.

Mallophaga.—These are small, flat, wingless insects (fig. 6) with short legs and a large head, with short antennæ. Since most of these occur on birds, they are commonly called "bird-lice." They have biting mouth-parts, feed upon feathers, hair, and dermal scales, and do not suck blood from the hosts. Several genera live upon mammals. The young are very similar to the adults. Many species are restricted to one host, but in some cases one species occurs on a number of related birds, and many birds harbor two or three different species. They may be preserved in alcohol, but are best studied when mounted upon slides.

Corrodentia.—The common members of this suborder (family Psocidæ) that occur around houses are known as "book-lice," but many others occur on the bark and leaves of trees and are called "tree-lice." They are all small insects, most of them with four wings, but the species occurring around houses are usually wingless. They are soft-bodied, with long antennæ and slender legs (fig. 7) and feed on minute plant life, on paste, hulls of seeds, etc. Many species are gregarious, at least during their immature stages, and some spin a web over their eggs. They fly at twilight. They should be mounted upon micropins, but when possible some should be preserved in alcohol.

FIG. 7.—A TREE-LOUSE, PSOCUS VENOSUS. (FROM COMSTOCK.)

ARCHIPTERA.

To this order belong the stoneflies, mayflies, and dragonflies, three groups that live for the greater part of the time as larvæ and nymphs in the water. Although there is no real metamorphosis, the younger stages differ from the adult in many ways besides the absence of wings. Together with the Platyptera, Neuroptera,

Trichoptera, and Mecaptera, they form the "neuropteroid" insects. There are three suborders, as follows:

Plecoptera. — The stoneflies (family Perlidæ) are soft insects with a rather slender, flattened body and large, many-veined wings (fig. 8). The antennæ are long and many-jointed, and in most cases there are two many-jointed caudal setæ. A part of the hind wings in the larger forms folds up like a fan. The adults take no food. The larvæ and the nymphs are aquatic, often found under stones in streams. The flies should be pinned and the wings spread; when possible, however, it is well to preserve some in alcohol.

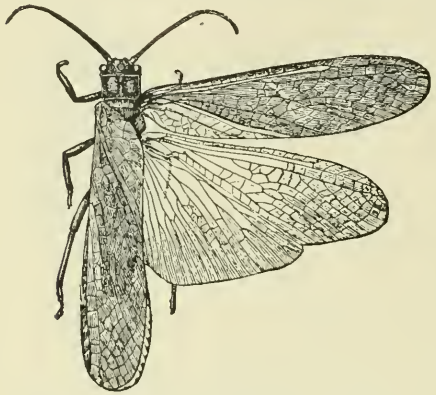

FIG. 8.—A STONEFLY, PTERONARCYS REGALIS. (FROM COMSTOCK.)

Anisoptera.—This suborder includes one family, the Ephemeridæ or mayflies (fig. 163 *b*, *c*), so called, since the adult fly lives but a brief period, longer, however, than one day. They are very fragile creatures, with very short antennæ and long, tapering bodies ending in two or three slender setæ, and have triangular, many-veined wings. The legs are slender and very weak. They have incomplete mouth-parts and take no food. Many species are attracted to electric lights in enormous numbers. A remarkable peculiarity is that after they have issued from the water and have wings, they molt again. This immature winged condition is called the "subimago," and may be distinguished from the adult by the fact that the margins of the wings are minutely ciliate. The larval and nymphal stages are passed in the water, many feeding on vegetation, but some are predaceous. They have leaf-like appendages or gills for breathing. They are a favorite bait with trout fishermen, and are the models for many of the artificial flies. Most should be pinned, but some specimens saved in alcohol.

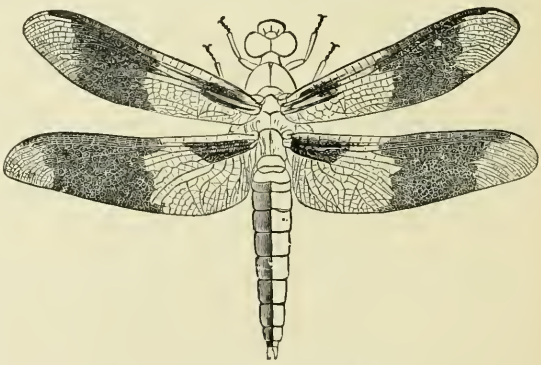

FIG. 9.—A DRAGONFLY, PLATHEMIS LYDIA. (FROM PACKARD.)

Odonata.—The dragonflies (fig. 9), "devil's darning needles," "snake doctors," etc., were familiar to every one of us when a child as objects of dread. However, they are perfectly harmless and may be handled without more than a slight pinch from a few of the larger sorts. They have long, slender bodies; long, many-veined wings; biting mouth-parts, and slender, bristly legs. The smaller kinds, called "damselflies," lay their wings together when at rest. They are predaceous, and catch many mosquitoes and other small Diptera. The larvæ and nymphs are ferocious inhabitants of ponds and rivers, provided with extensile mouth-parts that can suddenly reach forward and catch an unsuspecting insect. The adult should be pinned and a slender hog-bristle pushed through the body from head to near the tail to prevent the loss of head, and keep the abdomen from bending downward. Some keep a few specimens of each kind in alcohol. The colors of some are apt to fade soon after death, so that color-notes should be made before killing the specimens.

FIG. 10.—AN EARWIG. (FROM PACKARD.)

ORTHOPTERA.

The members of this order have biting mouth-parts, and four stiff, many-veined wings. Those of the front pair, called tegmina, are long and thickened, and usually overlap at base when at rest. Those of the hind pair are large and fold up like a fan, and are hidden by the tegmina. The head is large, and the legs rather stout; often the hind pair is enlarged and fitted for jumping. The younger stages, except for the absence of wings, resemble the adult, and a number of species never acquires wings, or at least only rudimentary ones. Their food habits vary greatly, according to the groups. There are five distinct sections.

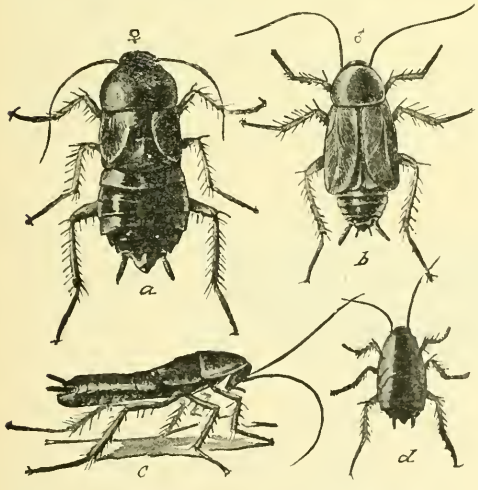

FIG. 11.—ONE OF THE COCKROACHES, BLATTA ORIENTALIS: *a*, FEMALE; *b*, MALE; *c*, SIDE VIEW; *d*, YOUNG.

(1) The Dermaptera (Forficulidæ), or the earwigs (fig. 10), differ from the other forms in having a pair of crude, forceps-like appendages at the tip of the body. The idea that they get into ears is

entirely erroneous, for these tiny insects are quite harmless, and feed on decaying matter. The hind wing of these earwigs is a very peculiar structure, unlike the wings of any other insect.

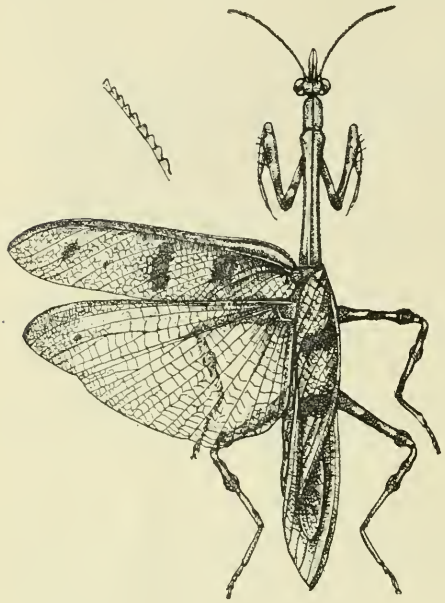

FIG. 12.—A MANTID, VATES TOWNSENDI.

(2) The Cursoria includes the family Blattidæ or cockroaches, too familiar to inhabitants of cities. They have long, threadlike antennæ, and slender, spiny legs, and in many the wings are very short or even absent (fig. 11). The eggs are laid in cases, called "öotheca," which the female carries about for some days. They usually feed on decaying vegetable matter.

(3) The Raptoria (family Mantidæ) and (4) the Ambulatoria or walking-sticks (family Phasmidæ) are both most numerous in tropical countries. To the former belong the leaf-insects, and to the latter the stick-insects, both striking examples of protective resemblance. The Mantidæ (fig. 12) lay their eggs in a large mass attached to a tree or fence. They have the first pair of legs enlarged and spiny, with a short claw near tip. They stand motionless for hours with their raptorial front legs extended, a position which has won them the name of praying mantis. Their prayer, however, is for prey. The Phasmidæ (fig. 150) are strict vegetarians.

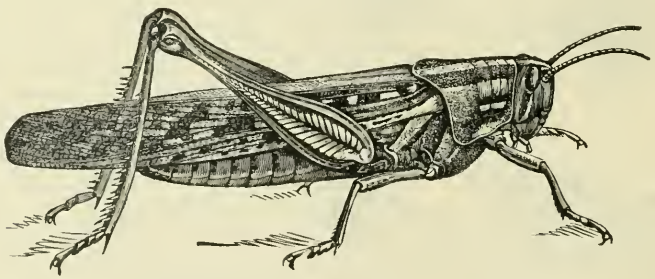

FIG. 13.—A GRASSHOPPER, SCHISTOCERCA AMERICANA.

(5) The Saltatoria includes the grasshoppers, meadow locusts, and crickets. These forms are very common in our country and are recognized by having enlarged hind femora. The grasshoppers (family

Acridiidæ) have short antennæ. The two other groups have extremely long and many-jointed antennæ, and also differ from the grasshoppers in having a prominent ovipositor.

The grasshoppers (figs. 13, 151) (or locusts), as is well known, are often very destructive to crops. They usually deposit their numerous eggs beneath the soil in late summer or autumn, the young hatching in the spring and feeding on the adjacent vegetation. Some species, as the "Rocky Mountain locust," at times become so numerous that they are obliged to migrate to obtain food. These migrating swarms were formerly a tremendous scourge to the western farmers, but now their breeding grounds have been largely destroyed by cultivation. Grasshoppers are more numerous in species in the prairie regions than elsewhere in the country. Several species can make a noise by their wings when in flight.

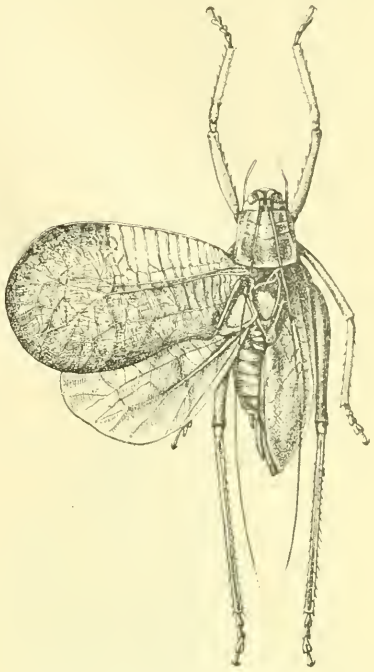

FIG. 14.—THE KATYDID, CYRTOPHYLLUS PERSPICILLATUS.

Quite a number of meadow locusts and katydids (family Locustidæ) are predaceous and feed on plant-lice or other small insects. They are commonly green in color, and

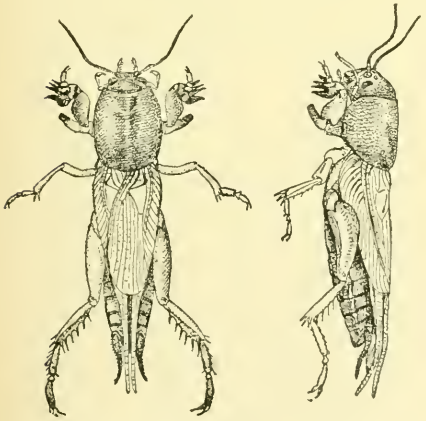

FIG. 15.—A MOLE-CRICKET, SCAPTERISCUS DIDACTYLUS.

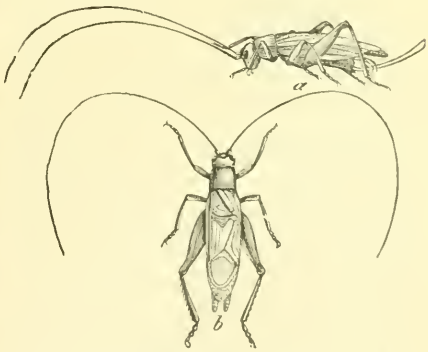

FIG. 16.—A TREE-CRICKET, OROCHARIS SALTATOR: *a*, FEMALE; *b*, MALE.

occur on shrubs or in grass, where they are not readily noticed. The males of all the species can make sounds by rubbing the base of one

wing over the other. This part of the wing is especially modified to make the sound. Each species has a characteristic note, which can be recognized by one familiar with them. The katydid (fig. 14) lives in the tops of trees, and though the telltale notes are well known to many, the insect is rarely seen by anyone.

The crickets (family Gryllidæ) are very similar to the meadow locusts, but have only three joints to the tarsi, while the locusts have four. The males of both groups have a special singing organ, a modification of the veins at the base of the wings. Some crickets (fig. 15), known as mole crickets (*Gryllotalpa*), are very different from the others, and have their front legs fitted for digging in the soil. They also have short antennæ and lack the ovipositor. Most of the crickets are phytophagous, but those found on trees (fig. 16) are predaceous.

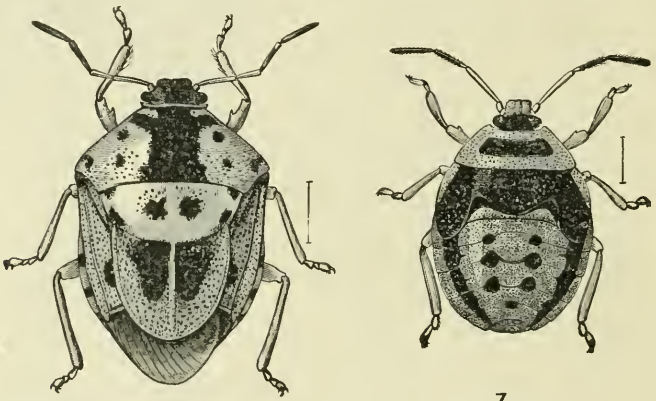

FIG. 17.—A PENTATOMID BUG, STIRETRUS ANCHORAGO: *a*, ADULT; *b*, NYMPH.

In all of these three families there are some short-winged or wingless forms (fig. 152), and sometimes a species varies in wing-length.

HEMIPTERA.

The Hemiptera, or Rhynchota as they are known to many Europeans, differ from the members of all previous orders in the nature of their mouthparts. These are slender and needlelike and form a beak fitted for sucking liquids, as blood, or the sap of plants. It is to these insects that the entomologist applies the name "bug." The transformations are incomplete—that is, the young have much resemblance to the adults, and there is no resting stage. A few families (Coccidæ and Aleyrodidæ) have a more complete metamorphosis. There are four distinct groups, or suborders—the Heteroptera, Homoptera, Phytophthires, and the Anoplura.

The HETEROPTERA have the basal part of the forewings hardened and thicker than the apical part, and the apical parts cross flatly when at rest. The beak arises from the front part of the head. With most of the Heteroptera (see fig. 17) the head is much smaller than the thorax

and triangular in shape. Many of the species can cause considerable pain by puncturing the skin with their sharp-pointed beak. They also have the power of emitting when disturbed a nauseous odor, which comes from drops of fluid secreted from two pores on the under side of the thorax. Most of the species feed on plants, but

FIG. 18.—THE BED-BUG, CIMEX LECTULARIUS.

FIG. 19.—A COREID BUG, LEPTOGLOSSUS OPPOSITUS.

several families are predaceous. Quite a number of Heteroptera live in moist places. The chinch bug and squash bug are well-known members of this group, which includes also the notorious bed-bug (fig. 18) of many aliases. The latter creature is never winged, and also does not occur under the bark of trees in the woods.

Many species deposit their eggs in clusters on the food plant; others insert the eggs in the plant tissue. Most have but one generation a year, passing the winter in the adult condition under loose bark or among fallen leaves.

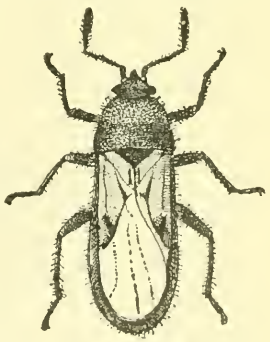

FIG. 20.—THE CHINCH BUG, BLISSUS LEUCOPTERUS, A LYGÆID.

There are many families, the most prominent of which are the following:

The Pentatomidæ (fig. 17), which have five-jointed antennæ, and the body rather broad, with short head, and legs of moderate length. Most are brown or green in color, but some are prettily marked in bright colors.

The Coreidæ (fig. 19), which have rather longer bodies, four-jointed antennæ, a four-jointed beak, and legs of moderate length; often some of the legs are enlarged, or have membranous expansions.

The Lygæidæ (fig. 20), very similar to the Coreidæ, but all are much smaller, and with fewer veins in the membrane of the wing. Many of them live on the ground.

The Reduviidæ (fig. 144), which have four-jointed antennæ, a three-jointed beak, and simple eyes, or ocelli. The body is rather slender. All members of this family are predaceous.

The Capsidæ (fig. 21), with four-jointed antennæ and beak, without ocelli, and with only two cells in the membrane of the wing, are small, delicate, rather slender insects most of which feed on plants.

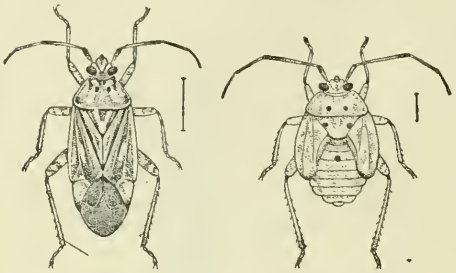

FIG. 21.—ONE OF THE CAPSIDÆ, LYGUS PRATENSIS.

The Tingitidæ, or lace bugs (fig. 22), feed on the under surface of leaves of various trees.

The Cryptocerata, with the antennæ almost invisible, includes a number of aquatic bugs (figs. 145, 146) of very diverse structure and habits. Some are the largest species of the order, such as the *Belostoma* or "electric light bug."

The arrangement of these families is still a subject of much discussion, but is usually in two groups: Hydrocorisa (water bugs) and Aurocorisa (land bugs); Gymnocerata (visible antennæ) and Cryptocerata (hidden antennæ); or Trochalopoda and Pagiopoda, according to the nature of the coxal joint.

The HOMOPTERA differ from the Heteroptera in having the forewings of even texture throughout, and the tips do not lap over one another when at rest. Moreover, the beak in the Homoptera appears to arise from the posterior end of the head beneath, and the antennæ are very short, with a fine terminal bristle. The Homoptera are mostly small insects, and all feed on vegetation. Nearly all of them are expert jumpers, although they do not have any enlarged legs. They are commonly known as leafhoppers (Jassidæ), treehoppers (Membracidæ), froghoppers (Cercopidæ), etc.

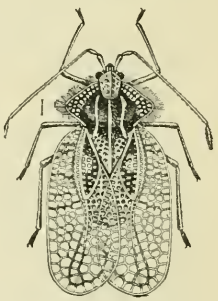

FIG. 22.—A TINGITED BUG, GARGAPHIA ANGULATA.

The Jassidæ (fig. 23) are small and slender insects, abundant in meadows, and sucking the juices from plants. Many of them are green or brown in color, but some are striped or spotted with red or pale. The Membracidæ (fig. 24) have the prothorax enlarged to cover most of the body. Usually they are elongate triangular from above, and with folded wings and legs drawn up they have little resemblance to an ordinary insect. The Cercopidæ are usually diamond-shaped insects; the young often live in a mass of froth or spittle, which they produce as they suck the juices from the plants.

To this suborder belongs the cicada (fig. 25), or "locust," whose shrill voice is a familiar sound in summer. They are the largest insects of this suborder, and many of the tropical forms are of beautiful coloration. One of these cicadas, the seventeen-year form, spends seventeen years under ground as a young insect, and then issues in great numbers. The tropical lanternfly, of the family Fulgoridæ (see fig. 147), is also a member of this group.

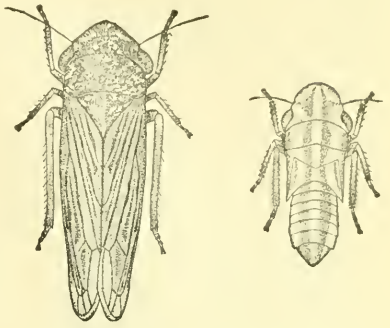

FIG. 23.—ADULT AND YOUNG OF A LEAFHOPPER, OR JASSID, ONCOMETOPIA LATERALIS.

The suborder PHYTOPHTHIRES includes many small insects known as plant-lice or aphids, and scale insects or coccids. Their antennæ are long, without apical bristle, and their wings are filmy. The plant-lice (family Aphidæ) occur in great numbers on many plants and are a familiar nuisance to the growers of flowers and indoor plants. They have a winged and a wingless stage, and they increase largely by a sort of budding process without depositing eggs. Plant-lice (fig. 26) include some of our most destructive insects, as the grape Phylloxera, hop aphis, and apple aphis. Many species live on different plants at different portions of their lives. The Psyllidæ (fig. 148), or jumping plant-lice, are similar to the plant-lice, but rarely occur in such numbers and always increase by the deposition of eggs, as do most other insects. Some of them produce galls. The Coccidæ, or scale insects (fig. 149), includes the notorious San Jose scale, mealy bugs (fig. 27), and other similar forms. In these the male only is winged, and then with but one pair, while the female remains attached to the twig or leaf, a mere protuberance with little resemblance to an ordinary insect. The male, unlike other Hemiptera, passes through a complete metamorphosis. The adult male has no mouth-parts and does not feed, while the female has a long flexible beak with which she sucks

FIG. 24.—A TREE-HOPPER, OR MEMBRACID, CERESA BUBALUS: *a*, SIDE VIEW; *b*, TOP VIEW.

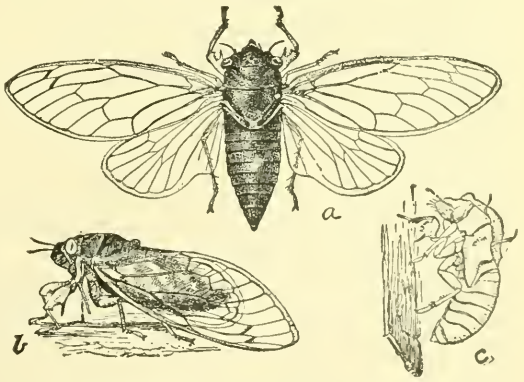

FIG. 25.—THE 17-YEAR LOCUST, TIBICEN SEPTENDECIM: *a*, WITH WINGS SPREAD; *b*, WITH FOLDED WINGS; *c*, NYMPH.

up the sap of the plant. Although many species are very destructive, there are several very useful insects, such as the cochineal and lac insects; the former used for a dye, and the latter to make shellac.

The suborder ANOPLURA (Pediculi) includes a few wingless parasites known as lice (fig. 28), which infest various mammals, including man. They are flat, with short legs, the tips of which end in a large claw opposed to a projection from the preceding joint. They should be collected in alcohol; or, for study, mounted upon slides, always with the name of the host.

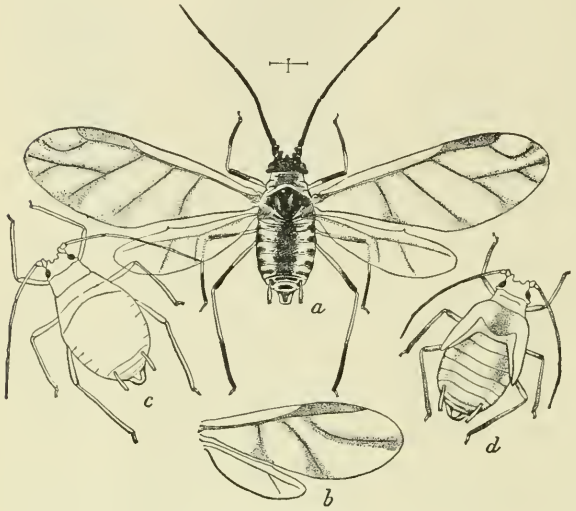

FIG. 26.—A PLANT-LOUSE, RHOPALOSIPHUM VIOLÆ: *a*, ADULT; *b*, WINGS; *c*, LARVA; *d*, NYMPH.

THYSANOPTERA.

This small order is based on tiny insects known as "thrips" (fig. 29). They are slender, rather flat, with pointed head, and short legs which end in two-jointed tarsi without claws. The four wings are very slender, with few veins, and fringed with long hairs. A few species, however, have apterous females. Their mouth-parts are peculiar, and their metamorphosis is incomplete. They feed on vegetation and are quite numerous, and many fly during fine days in the autumn and may be seen on clothing, in houses, etc. Others hibernate under loose bark. All should be mounted upon slides, care being taken to spread out the wings.

FIG. 28.—THE HEAD LOUSE, PEDICULUS CAPITIS.

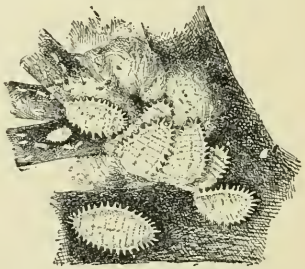

FIG. 27.—A MEALY BUG, DACTYLOPIUS CITRI.

NEUROPTERA.

These are biting insects with four large, many-veined wings, and a complete or nearly complete metamorphosis. The legs are of moderate size, and the tarsi have five joints. They are a small order, and as many fly only at night they are not often seen by the general collector of insects. There are three suborders. The Megaloptera include large species like the horned Corydalis or hell-

gramite fly, whose larva, known as the Dobson, is to be found in most of our running streams. The insects of the suborder Stegoptera are smaller, more delicate insects, which fold their wings roof-like over the body. The ant-lion flies (Myrmeleons) (fig. 30), whose larvæ (fig. 31) make funnel-shaped pits in sand in the bottom of which they wait with extended jaws for any small insects that may tumble into the trap, belong to this group. The gauzy lacewing flies (*Chrysopa*) (fig. 32) or "golden eyes," have a spindle-shaped predaceous larva which wanders over leaves in search of plant-lice. The parent fly of many species deposits the eggs in clusters at the tips of slender wiry stalks. Some of the species have an extremely vile odor. The Mantispidæ (fig. 153) have the front legs enlarged and spiny, with which they catch small insects. The young are parasitic in egg sacs of wandering spiders. The suborder Mecaptera (Panorpidæ) (fig. 154) are flies having the head prolonged below. The body is slender and cylindrical. In the male it terminates in a pair of large claspers, from which these insects obtain the common name of "scorpion-flies." They catch and eat small insects. Their larvæ resemble the true caterpillars, but have eight pairs of abdominal legs. These larvæ live in the soil and are predaceous, but are very rarely found, although the adult flies are common in the Eastern States.

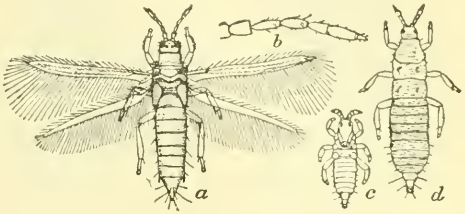

FIG. 29.—ONE OF THE THYSANOPTERA, THRIPS TABACI: *a*, ADULT; *b*, ANTENNA OF SAME; *c*, YOUNG LARVA; *d*, FULL-GROWN LARVA.

FIG. 30.—AN ANT-LION, OR MYRMELEON. (FROM PACKARD.)

COLEOPTERA.

The Coleoptera, or beetles, as they are universally called, are the insects most common to all observers. Their fore-wings, called elytra (singular, elytron) are hard or leathery, and when at rest meet down a straight line on the back. They show few traces of veins, and beneath them are folded the other wings, which, though of moderate size, are sufficient for good flight. In numbers the beetles outrank all other orders. Some, if not the largest, are the weightiest of insects, and others are so tiny as to be scarcely visible to the unaided eye. The ease with which they may be collected and preserved, together with the bright colors of many species, have made the order a very popular one with collectors.

FIG. 31.—A MYRMELEON LARVA.

Beetles pass through a complete metamorphosis. The larvæ show great variety in shape and structure, but are often elongate, rather flat creatures, with or without legs, and with strong biting jaws. The pupa shows the legs and antennæ of the adult folded against the body, and the wing-pads are applied to the sides. Several arrangements of the beetles in large groups or sections have been proposed by coleopterists, yet none of such striking superiority as to command general adoption. In Europe, Professor Kolbe and Doctor Ganglbauer have proposed new systems of Coleoptera, which have many valuable points; however, a slight modification of the arrangement used by Doctors Le Conte and Horn is as useful, and probably as natural, as any other. It divides the beetles into seven sections, as follows:

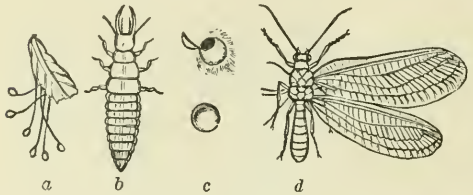

FIG. 32.—A LACEWING FLY, CHRYSOPA: *a*, EGGS; *b*, LARVA; *c*, COCOONS; *d*, FLY WITH LEFT WINGS REMOVED.

Adephaga.—The antennæ are simple, not with leaflike plates nor enlarged at tip; all the tarsi five-jointed. The mouth-parts are usually well developed, and the abdomen shows six segments on the under side. The larvæ are usually very active and commonly predaceous. They have a tapering body, widest near the middle, with prominent head and jaws, prominent legs, ending in two claws, and frequently one, two, or three terminal processes or tails to the body. Many of the species are aquatic (Dytiscidæ, fig. 128). Others are called ground-beetles (figs. 33, 127) and tiger-beetles. The tiger-beetles (fig. 129) (Cicindelidæ) are usually of very brilliant coloration, but most of the beetles (Carabidæ) of this section are black or at least without particular markings.

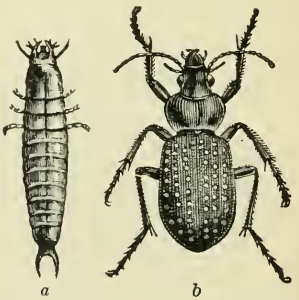

FIG. 33.—A GROUND-BEETLE, CALOSOMA CALIDUM: *a*, LARVA; *b*, ADULT.

Clavicornia includes those beetles with the antennæ enlarged at the tip (fig. 123). This section comprises a great number of species, usually of small size, but of great diversity of structure and habit. The tarsi in most of the families are five-jointed, but many of the smaller species have but three-jointed tarsi. The head is commonly much smaller than the thorax, and often bent under or partly depressed. Most of their larvæ are predaceous, but many feed on dead animals or vegetable matter, stored foods, in ants' nests, and a few on living plants. The larvæ exhibit very diverse characters, but usually they are more cylindrical than those of the Adephaga and with less prominent legs, and when there are terminal processes or tails they are less long than in the Adephaga. To this section belong the prettily spotted ladybird

beetles (Coccinellidæ) (fig. 34) which are very beneficial to mankind, since both beetles and larvæ destroy countless thousands of aphides and

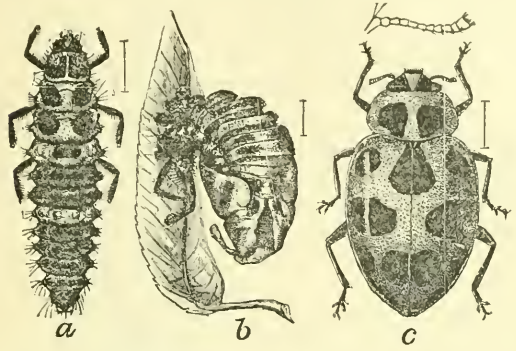

FIG. 34.—A LADYBIRD, MEGILLA MACULATA: *a*, LARVA; *b*, PUPA; *c*, BEETLE.

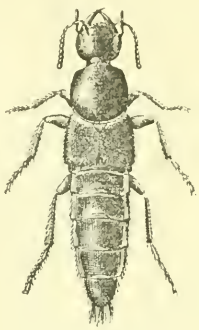

FIG. 35.—A ROVE-BEETLE, PHILONTHUS.

scale insects. One of these, the famous Vedalia ladybird, destroyed the Icerya scale insect that was ruining the orange orchards of California.

An immense family, the rove-beetles (fig. 35) (family Staphylinidæ), have long slender bodies, and the elytra are very short, not half covering the abdomen. The carrion-beetles (Silphidæ) (fig. 130) are common around dead animals; they are mostly broad and flat. Some species (family Hydrophilidæ) are aquatic, like the dytiscids of the previous section.

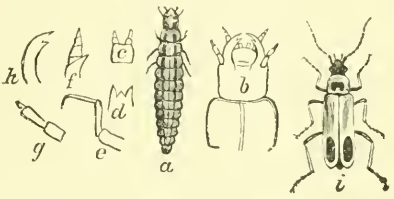

FIG. 36.—A SOLDIER-BEETLE, CHAULIOGNATHUS PENNSYLVANICUS: *a*, LARVA; *b-h*, PARTS OF LARVA ENLARGED; *i*, BEETLE.

The *Serricornia* includes a few families of beetles (fig. 36) in which the antennæ are not enlarged at tip but are serrate or saw-like beneath. The body is often elongate, with subparallel sides. The head is small, but distinct from above. The legs are quite slender, and the tarsi five-jointed. The adults are often found on flowers or on leaves, but do not eat much. Some of them are called click-beetles (fig. 37) (Elateridæ), since when laid upon their back they can spring into the air accompanied by a clicking noise. This section also includes the fireflies (family Lampyridæ), whose intermittent light on a summer evening is familiar

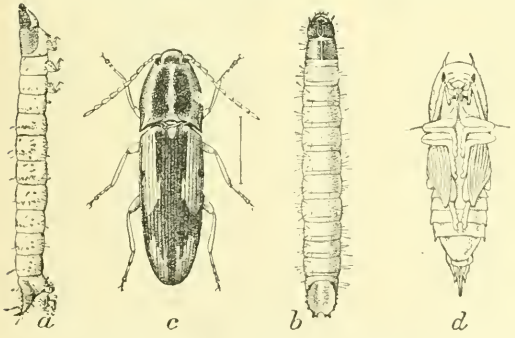

FIG. 37.—A CLICK-BEETLE, MONOCREPIDIUS VESPERTINUS: *a*, LARVA FROM SIDE; *b*, LARVA FROM ABOVE; *c*, BEETLE; *d*, PUPA.

to all. Many species are dull colored, but the Buprestes are among the most brilliant and gorgeous of the insect tribe. The larvæ of this section are variable. Those of the Buprestes (figs. 38, 126) bore in wood, have enlarged heads, and are without legs. The larvæ of other families, however, have short legs, and in many cases the last segment is corneous and toothed. Some of them are predaceous; others live in decaying or in living wood.

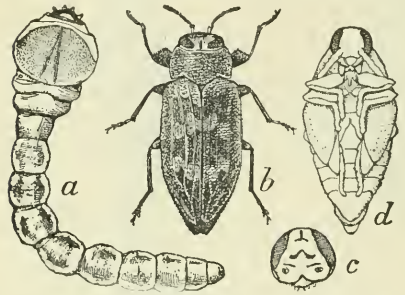

FIG. 38.—A BUPRESTID, CHRYSOBOTHRIS FEMORATA: *a*, LARVA; *b*, BEETLE; *c*, HEAD OF MALE; *d*, PUPA.

Heteromera. — This section includes those beetles whose antennæ are simple (not clavate or serrate), and which have but four joints in the hind tarsi, the tarsi of the anterior legs having five joints. The ventral side of the abdomen shows but five segments. The beetles of this section are of various shapes. Many of them are dull colored. The head is usually prominent, and the legs quite slender. Some of them have no hind wings. Most of them feed on vegetation, others in stored foods, and some (Meloidæ) are parasitic in the nests of wasps, bees, or on the eggs of grasshoppers. The latter pass through a complicated life history, the first larva looking much like that of the Adephaga, while later the larva is a fat grub like that of the June bugs. Other larvæ are hard-bodied and rather slender. To this section belong the blister-beetles (Meloidæ) (fig. 118) and the mealworm (Tenebrionidæ, fig. 39) and the small flower-beetles (Mordellidæ), with compressed tapering bodies, which slip through the fingers when one catches them.

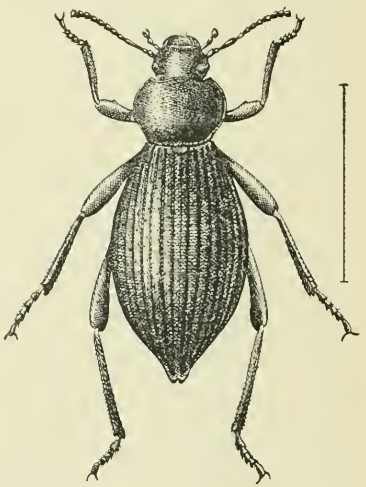

FIG. 39.—ONE OF THE TENEBRIONIDÆ, OR DARKLING BEETLES, ELEODES.

Phytophaga.—This section includes a large series of beetles (fig. 40) in which the tarsi are apparently four-jointed, the basal three usually provided with dense, short hairs forming a sort of cushion. The head is usually bent downward, and the mouth is below. The antennæ are simple, and often very long. The legs are short and stout. In some cases the hind pairs are thickened for leaping. The larvæ of all feed on plants, either on the leaves, in the wood, or on the seeds. The adults in many cases also feed on the same materials. Many of them are very prettily marked with spots and stripes of various colors. A

considerable number can make noises when disturbed. Most of their larvæ have short legs, but some of the wood-boring kinds are apodous, or legless. In nearly all the last segment is not corneous or toothed, but in one group of leaf-beetles (Cassidæ) the last segment, as well as other segments, shows a marvelous development of spines and projections. The long-horned beetles (Cerambycidæ) (fig. 120), the leaf-beetles (Chrysomelidæ) (figs. 121, 124), of which the potato "bug" (fig. 41) is an example, and

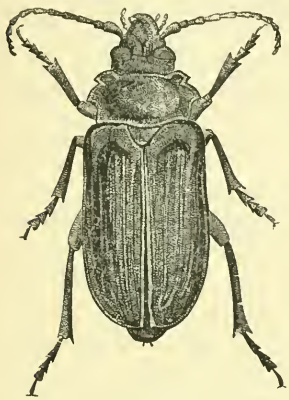

FIG. 40.—A LONGICORN, PRIONUS LATICOLLIS.

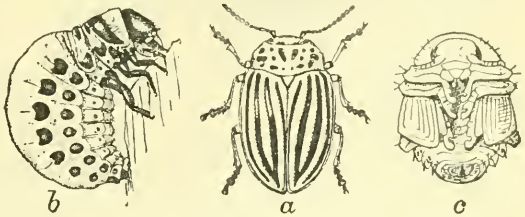

FIG. 41.—THE COLORADO POTATO "BUG," LEPTINOTARSA 10-LINEATA: *a*, BEETLE; *b*, LARVA OR GRUB; *c*, PUPA.

the bean and pea weevils (Bruchidæ) (fig. 125) belong to this section.

Rhynchophora, or weevils. This section comprises an enormous number of compact beetles, readily known by the snout or beaklike head, called a rostrum. The tarsi are four-jointed. The mouth-parts are very small and at the tip of the beak, and the antennæ are often slightly clavate and geniculate or bowed. The elytra are usually very hard, and in a number of species there are no hind wings. Most of them belong to two or three families, Curculionidæ (fig. 42), Calandridæ (fig. 119), or Otiorhynchidæ, but are similar in appearance. Both adults and larvæ are phytophagous, feeding on leaves, on the seeds, on fruits, in wood, or on plants. The larvæ are grublike, soft-bodied, usually curved, without legs or with only very short ones, and the last segment is not hardened or produced. The famous cotton-boll weevil (*Anthonomus grandis*), the plum curculio (*Conotrachelus nenuphar*) (fig. 43), the grain weevil (*Calandra oryza*), and many other injurious beetles belong to this section. They are very abundant in tropical countries, and often of very brilliant coloration. Allied to them are the Scolytidæ, barkbeetles, or engraver-beetles (fig. 161), which are very destructive to timber. They are small and dark colored, with

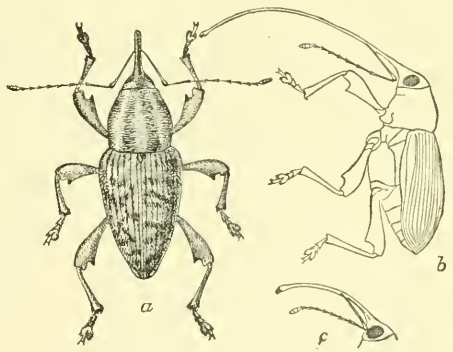

FIG. 42.—A CHESTNUT WEEVIL, BALANINUS RECTUS: *a*, TOP; *b*, SIDE; *c*, HEAD.

blunt head and knobbed antennæ. The burrows (fig. 162) of the beetles and larvæ in wood and under bark are often of a characteristic pattern for each species.

Lamellicornia.—The beetles (fig. 44) of this section have the last few joints of their short antennæ developed into leaf-like extensions. The tarsi are five-jointed. Many of them are of large size (fig. 122), with broad, heavy bodies, and in many cases the males have curiously developed horns on the head or prothorax. Their legs are rather short, and usually end in very stout claws. Some of them have the forelegs toothed and fitted for burrowing in the soil. Many of the tropical species are renowned for the beauty and elegance of their form and color. The larvæ are fat grubs, with very short legs, a prominent head, and a thick, soft abdomen. They often lie in a half-curled position. The adults are frequently found upon flowers, and many eat the leaves of plants. The larvæ live in the soil, feeding upon roots, or in manure, or in decaying wood, or in ants' nests. To this section belong the sacred Scarabæus of the Egyptians, the familiar June-bugs or May-beetles (family Scarabæidæ), and the stag-beetles (Lucanidæ), the males of which have enormous jaws.

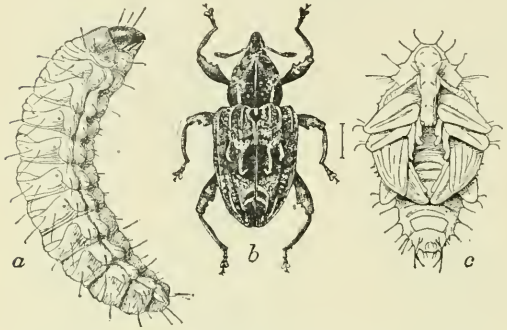

FIG. 43.—THE PLUM CURCULIO, CONOTRACHELUS NENUPHAR: *a*, LARVA; *b*, BEETLE; *c*, PUPA.

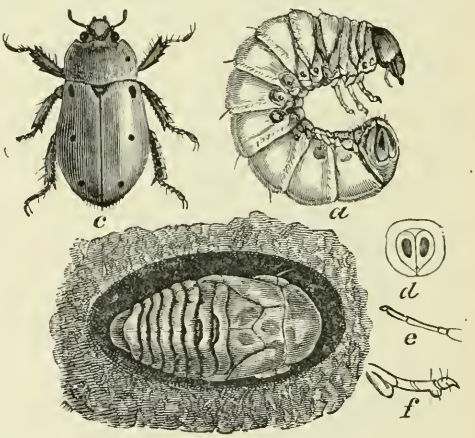

FIG. 44.—A LAMELLICORN, PELIDNOTA PUNCTATA: *a*, LARVA; *b*, PUPA; *c*, BEETLE; *d*, *e*, *f*, ENLARGED PARTS.

STREPSIPTERA.

This order (family Stylopidæ) includes a few tiny insects whose curious structure and habits have long puzzled entomologists. The male has large eyes and a short, small abdomen. The elytra are very rudimentary. These males live but a short time, but are very active. The female is a mere sac, a head and a larger body, without legs and wings. The larvæ and the female live in the bodies of other insects, wasps, bees, and certain Hemiptera. They pass through a com-

plicated metamorphosis. The first larva, called a triungulin, is a minute insect with six long legs and a pair of bristles at tip of body. All stages should be mounted upon slides.

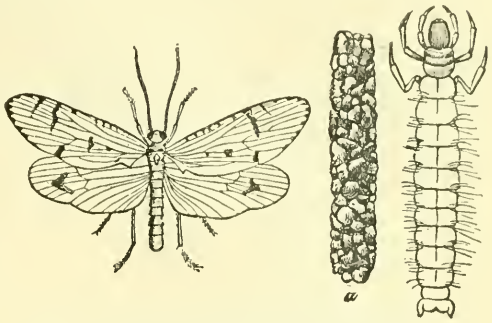

FIG. 45.—A CADDICEFLY, LARVA, AND ITS CASE. (FROM PACKARD.)

TRICHOPTERA.

This order includes the caddiceflies (fig. 45), or watermoths. They have a general resemblance to moths, or millers, but have hairs instead of scales upon the wings and body. Many are attracted to electric lights. The antennæ are slender and simple, the hind wings broader than the fore pair, and the posterior part folds as a fan. The adult insects have very weak mouth-parts and take no nourishment. The larvæ and pupæ live in the water of ponds and streams. Many of them make cases of pebbles, sticks, or leaves, which they carry about with them. Others spin a web or net in the water. The former live upon aquatic vegetation; the latter are predaceous. They pupate within their cases, closing up the entrance with a mesh of threads. None of them are of economic importance, and they are most abundant in the colder parts of the country.

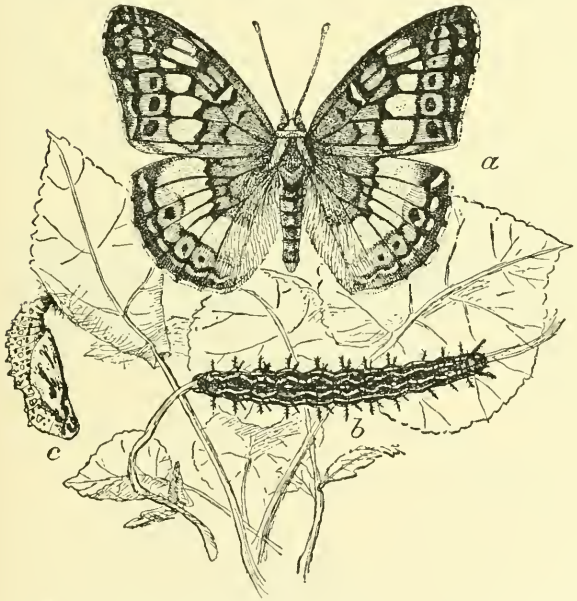

FIG. 46.—A BUTTERFLY, EUPTOIETA CLAUDIA: *a*, ADULT; *b*, CATERPILLAR; *c*, CHRYSALIS.

LEPIDOPTERA.

This order comprises the butterflies (figs. 46, 131, 132) and moths, or millers (figs. 133, 134, 158). The handsome colors of many species have made this order the most popular one with entomologists. The metamorphosis is complete, and the transformation from the pupa or chrysalis to the butterfly has been a marvel to all observers, and frequently applied to human life. The beauty of these frail

insects is due to the scales that cover the wings and body. These scales are of various shades and structure, and so placed as to overlap each other. Their colors range from the most brilliant to the most delicate, and often display a glittering iridescence unapproachable by any human artifice; and the pattern in which the colors are arranged is often of the most attractive and exquisite design, the delight of childhood and the admiration of age.

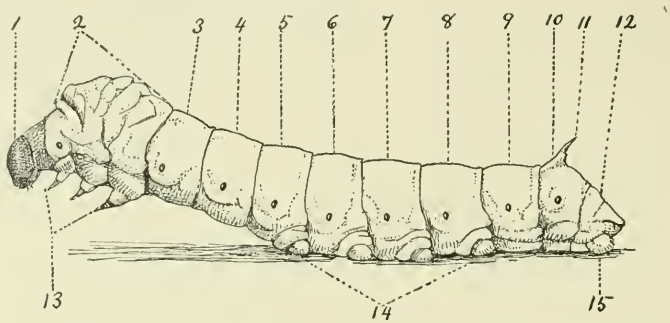

FIG. 47.—A CATERPILLAR: 1, HEAD; 2, THORAX; 3 to 10, SEGMENTS OF BODY; 11, HORN; 12, LAST SEGMENT; 13, TRUE LEGS; 14, FALSE LEGS OR PROLEGS; 15, ANAL CLAWS.

The mouth-parts of the Lepidoptera are modified to form a long proboscis, haustellum, or sucking tube, which is usually carried rolled up under the head and hidden by scales. In some species, as the hawk moths, this proboscis is very long, so that the moth may hover in front of a flower, insert the tube to the bottom of the flower, and extract the nectar. The young, or caterpillars (fig. 47), are of very diverse appearance, but usually elongate, with a distinct head and three pairs of legs. Behind these true legs are several pairs of fleshy prolegs, which assist in crawling. These are from four to ten in number. These caterpillars are often provided with hairs, bristles, or spinous projections. All (with a very few exceptions) feed on vegetation, usually living plants, and consequently do a great deal of damage.

FIG. 48.—A SPHINGID, AMPELOPHAGA MYRON.

The generally accepted division of the Lepidoptera is that of butterflies (Rhopalocera) and moths (Heterocera). The butterflies as a rule have the antennæ clavate or knobbed at tip, hold their wings erect when at rest, fly by day, and they do not spin a cocoon to inclose the pupa, which is placed above ground. Many of the butterflies have

common names; the large "swallow-tails" (Papilios) are known to every country child. One family of the butterflies, the Hesperidæ, or "skippers," have the antennæ terminating in a point, and some

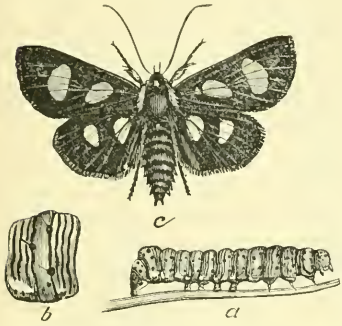

FIG. 49.—THE EIGHT-SPOTTED FORESTER, ALYPIA OCTOMACULATA: *a*, LARVA; *b*, ENLARGED SEGMENT OF SAME; *c*, MOTH.

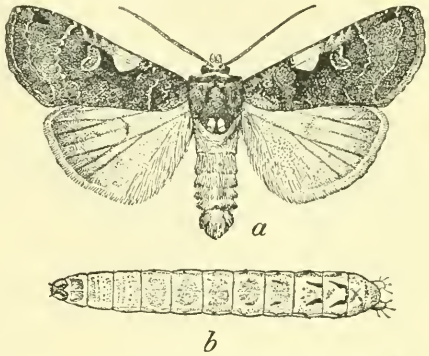

FIG. 50.—A CUTWORM MOTH, NOCTUA C-NIGRUM: *a*, MOTH; *b*, CATERPILLAR.

entomologists believe they should form a third primary division called Grypocera.

The moths have the antennæ of various shapes, but not knobbed at tip. The wings are usually depressed at rest. They are mostly nocturnal in their habit, and the pupa is usually within a silken cocoon

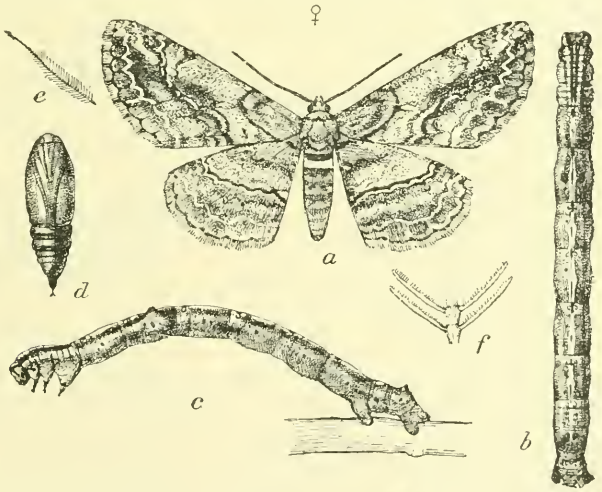

FIG. 51.—A GEOMETRID, CLEORA PAMPINARIA: *a*, MOTH; *b*, *c*, CATERPILLAR; *d*, PUPA; *e*, *f*, ENLARGED PARTS.

spun by the larva. The Sphinges, or hawk moths (fig. 48), are intermediate in habit, flying mostly at twilight, and their antennæ, although thicker near tip, terminate in a fine point much like those of

the "skippers." Their larvæ are large, smooth caterpillars, often with a horn near tip of body. The old group of Bombyces (fig. 49), now divided and scattered, included some of the largest species of the order. The pale green Luna moth and the American silkworm, or Cecropia moth, are well-known forms. The Io moth has a green caterpillar, which can "sting" when handled. The gipsy moth also belongs in this group, as well as the silkworm moth, which, next to the honey bee, is the most valuable insect. The caterpillars of this group are usually spiny or hairy. Allied are the Noctuidæ, or owlet moths (fig. 50). They are rather stout-bodied, of moderate size, with dark colors. The caterpillars are smooth, and often known as cutworms. Among them are many of our most destructive insects, such as the bollworm and the cotton leaf-worm.

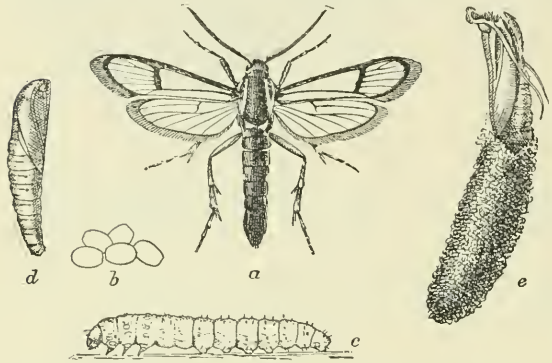

FIG. 52.—A SESIID, OR CLEAR-WINGED MOTH, SYNANTHEDON PICTIPES: *a*, MOTH; *b*, EGGS; *c*, CATERPILLAR; *d*, PUPA; *e*, PUPA IN CASE.

Another great group is the Geometridæ (fig. 51), whose larvæ have fewer prolegs than usual, and in consequence hump up their body when crawling, and so are called measuring worms. The moths have slender bodies and large wings, often of handsome shades and tints. The cankerworm belongs to this group. The slug caterpillars, which apparently have no feet and are often of curious shapes and bright colors, are the young of the Limacodid moths. One of these, the saddle-back caterpillar (fig. 135), will "sting" when touched, producing a sort of rash on the skin. The clear-winged, or Sesiid moths (fig. 52), are peculiar in that a part of the wings is destitute of scales. Their larvæ usually bore in the stems of plants and trees. The caterpillars of a small group of moths (Psychidæ) live in a case of leaves, which they carry about with them. One, the well-known bagworm (fig. 136), is often found upon evergreens, locust trees, etc.

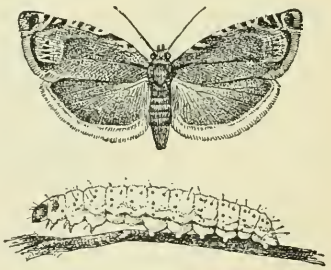

FIG. 53.—A TORTRICID MOTH AND ITS CATERPILLAR, SEMASIA NIGRICANA.

Several families of small moths (the Pyralidæ, Tortricidæ, and Tineidæ) are often grouped together by entomologists under the name of Microlepidoptera, or simply "Micros." The Pyralids (fig.

137) have rather triangular wings. Their larvæ often web up the leaves upon which they feed. The Tortricids (fig. 53) are known as leaf-rollers, since the larvæ of many species roll and fasten up the leaves, within which they feed and complete their transformations. Others, as the injurious codling moth, bore into fruit, stems, etc. The Tineid moths (fig. 54) are the most minute insects of this order, and many are of the most glittering colors. The larvæ of many kinds mine between the upper and under surfaces of leaves, forming sinuous lines or blisters. Others carry a case about with them, at least for a part of their lives. Their wings are long and slender, and their legs and palpi are often provided with dense brushes of scales.

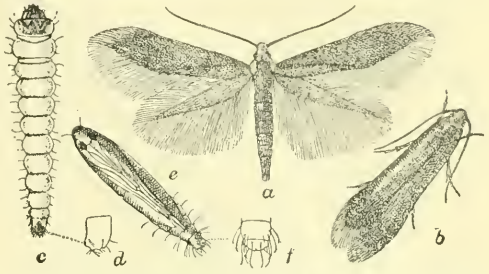

FIG. 54.—A TINEID MOTH, TISCHERIA MALIFOLIELLA: *a*, MOTH; *b*, SAME, WINGS CLOSED; *c*, CATERPILLAR; *c*, PUPA; *d*, *f*, ENLARGED PARTS.

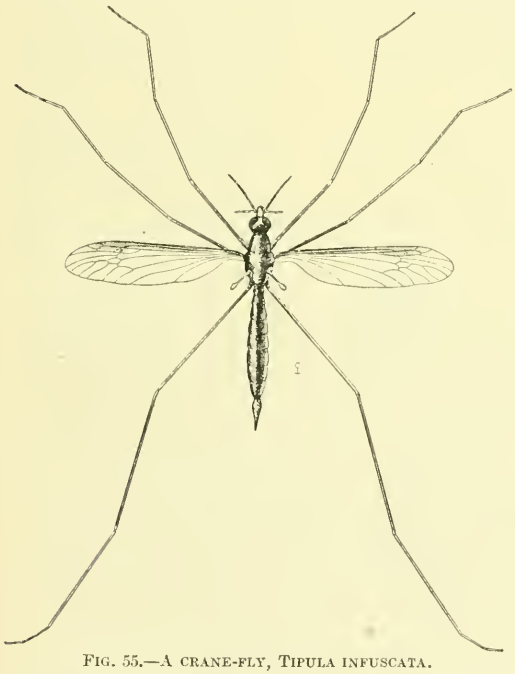

FIG. 55.—A CRANE-FLY, TIPULA INFUSCATA.

DIPTERA.

This order includes the true flies, those insects with but one pair (the anterior) of wings. The hind wings are replaced by a pair of short, slender, knobbed filaments called halteres, poisers, or balancers. The mouth-parts of Diptera are quite distinct from those of other groups, and formed for sucking liquids, but there is never a curled sucking tube like that of the Lepidoptera. The body is usually provided with hairs, bristles, or, in some cases, as the mosquitoes, with scales. The metamorphosis is complete. The larvæ are footless, and called maggots. The pupa is exposed, not in a cocoon, but in many forms the pupa is formed within the hardened larval skin. This is called a

coarctate pupa. The larvæ of many forms live in water, or at least in moist surroundings.

The classification usually adopted for the flies is that of Nemocera for those having long antennæ, and palpi of four or five joints. The pupa is naked, not coarctate, and the larvæ usually have a very distinct head. The Brachycera have very short antennæ, and palpi of one or two joints. The pupa is often coarctate, and the larvæ usually have no distinct head. The further arrangement of the groups is very unsettled. The suborder NEMOCERA can be arranged in three sections:

(1) The *Polyneura* (family Tipulidæ, or crane-flies (fig. 55),) are known from all others by the V-shaped suture on the thorax. Their legs are excessively long and fragile, and the wings and abdomen are also slender. The larvæ are slender, and often occur in water or moist places. Some, however, are abundant in fields.

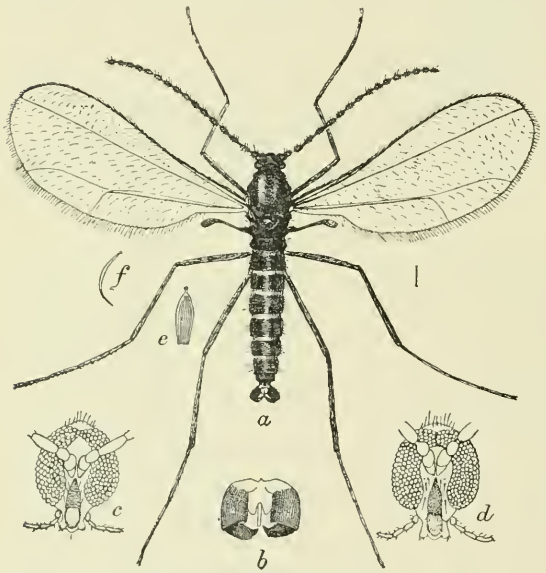

FIG. 56.—THE HESSIAN FLY, MAYETIOLA DESTRUCTOR: *a*, FLY; *b*, *c*, *d*, *e*, *f*, ENLARGED PARTS.

(2) The *Nemocera vera* have verticels or whorls of hairs on the antennæ. They have slender bodies and legs. The larvæ of the gall-gnats (Cecidomyiidæ) often produce galls on various plants. The Hessian fly (fig. 56) and wheat midge belong to this family. The Culicidæ, or mosquitoes, have scales on their wings. The larvæ (fig. 141) are aquatic, and familiar to most people as "wrigglers." Only the female mosquitoes can bite, and it is now known that several species transmit disease. The *Anopheles maculipennis* carries malaria, and the *Stegomyia calopus* (fig. 57) disseminates yellow fever. The Chironomidæ, or midges, with feathery antennæ, have aquatic larvæ, and the fungus-gnats (Mycetophilidæ), with long coxæ, breed in fungi, under loose bark, and in manure and decaying wood.

(3) The *Nemocera anomala* includes several small families which have no whorls of hairs on the antennæ, and in which the body and

wings are not slender. The black flies and buffalo gnats (Simuliidæ) belong to this group. They can bite very severely. Their larvæ occur in streams, and have long brushes near the head, and their pupæ have long filaments from the thorax.

The suborder BRACHYCERA is divisible into four sections:

(1) The *Orthorrhapha*, which do not have a coarctate pupa. The larvæ have a distinct head, and the last joint of the antenna is often long and sometimes shows annulations, and there is no frontal lunule or suture over the base of the antennæ. This section includes our largest flies. They are arranged in three groups: (*a*) The Eremochæta, which have the median projection, called an empodium, between the pads or pulvilli on the feet similar

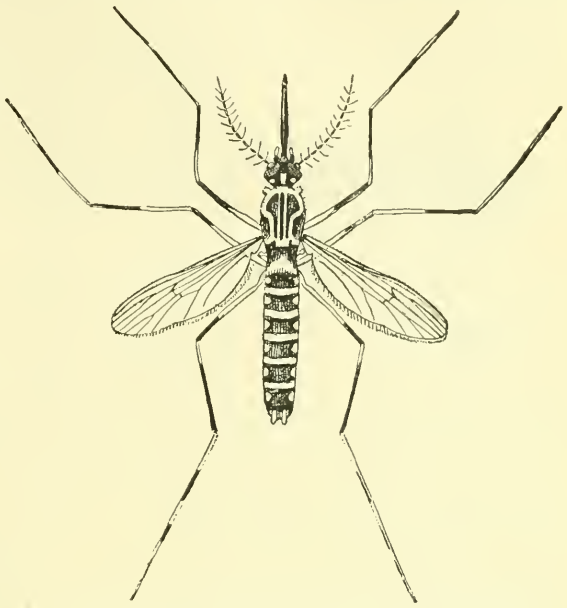

FIG. 57.—THE YELLOW-FEVER MOSQUITO, STEGOMYIA CALOPUS.

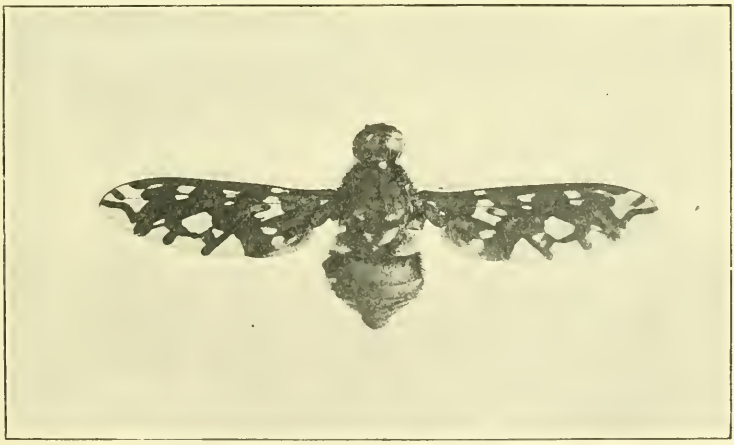

FIG. 58.—A BOMBYLIID FLY, SPOGOSTYLUM SIMSON.

in appearance to the pulvilli, and the third joint of the antennæ often shows annulations. There are no large bristles on the body,

and the legs are usually nearly smooth. The soldier-flies (Stratiomyiidæ), which have many markings on the body, the horseflies (Tabanidæ) (fig. 143), which annoy cattle as well as man, and the snipe-flies (Leptidæ), with slender, tapering bodies, belong to this group. Their larvæ are often aquatic, or live in moist situations. (*b*) The Tromoptera, or hovering flies, in which the empodium is bristle-like, much more slender than the pulvilli, or else absent. The third joint of the antennæ does not show any annulations. The legs usually have only fine hairs, and the body, especially the thorax, is often very hairy. The bee-flies (Bombyliidæ) (fig. 58), with pretty pictured wings, are in this group. Their larvæ are often predaceous or parasitic. (*c*) The Ernegopoda, which have strong, bristly legs, and often large bristles on the thorax. The empodium is slender or absent, and they are nearly all predaceous flies. The Asilidæ, or robber-flies (fig. 59), are the largest of these insects, while the Empididæ and Dolichopodidæ embrace a host of smaller forms.

FIG. 59.—A ROBBER-FLY, ERAX BASTARDII: *a*, PERFECT INSECT; *b*, PUPA; LARVA SHOWN AT SIDE.

(2) The *Aschiza* have the antennæ composed of three joints, with a tiny hair or arista near the tip. The head has no distinct lunule or arched suture near the base of the antennæ. The pupæ are coarctate. This includes the large family Syrphidæ (fig. 156), many of which are brightly and prettily colored, and the thick-headed flies or Conopidæ, which have the abdomen narrowed at base. Many of the larvæ of the Syrphids are predaceous and feed on plant-lice; others occur in mud, in foul water, in ants' and wasps' nests, and in bulbs of plants. The larvæ of Conops are parasitic in wasps and bees.

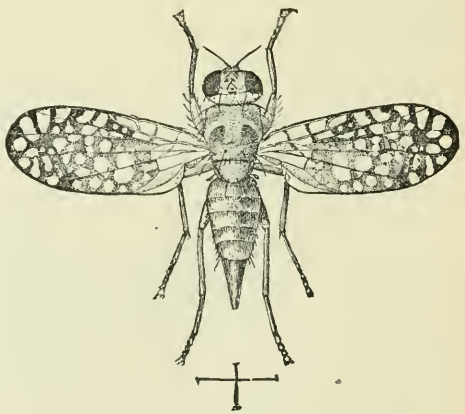

FIG. 60.—ONE OF THE TRYPETID FLIES, TRYPETA ÆQUALIS.

(3) The *Schizophora* have the pupa coarctate, the larvæ have no distinct head, and the antenna of the fly is of three joints and an arista, and the head shows a frontal lunule or arched suture near the base of the antennæ. This section includes two groups, one in which there is only one membranous piece or "calypter" each side above the haltere, the Acalypteræ; and the other group in which

there are two such pieces, the lower one much the larger, the Calypteratæ. The Acalypteræ includes many families of flies, mostly small and bristly. Some of them, like the Ortalidæ and Trypetidæ (fig. 60), have spotted or banded wings. Their larvæ occur in all sorts of places; some, like the apple maggot and the orange maggot, in fruit; others, like the frit fly, affect grains; others mine the leaves of plants, and many live in manure, or in moist soil.

FIG. 61.—A TACHINA FLY, ARCHYTAS PILIVENTRIS.

The Calypteratæ include the Tachina (figs. 61, 157) and Sarcophaga flies, with a bristly abdomen, the larvæ of which usually are parasitic in other insects. The Anthomyidæ are smaller, and their larvæ often attack vegetables. The cabbage maggot belongs to this family. The Œstridæ (bot or warble flies) (fig. 62) are hairy species whose larvæ live in various animals, sometimes in man. The true Muscidæ (fig. 63) include the hornfly, blowfly, house fly, stable fly, screw-worm fly (fig. 142), etc. Many of them are injurious to man or animals. The African tsetse flies are responsible for the Nagana disease of cattle, and the sleeping sickness of man. The ubiquitous house fly is one of the most dangerous insects, since it is known to assist in the spread of typhoid fever and possibly other diseases. The larvæ of a considerable number are occasionally swallowed by man with food. Such are the Sarcophaga, blowfly, and the fruit worms, and may cause slight intestinal troubles. This false or pseudoparasitism of dipterous larvæ in man is called "myiasis."

FIG. 62.—A BOT-FLY, CUTEREBRA CUNICULI.

FIG. 63.—A BLUE-BOTTLE FLY, LUCILIA CÆSAR, A MUSCID.

(4) The *Pupipara* occur on birds, bats, and domestic animals. Many are wingless, all rather flattened, with large, strong claws. The young are produced alive, full grown, but have to pass through the pupal stage.

SIPHONAPTERA.

This order, comprising a single family, Pulicidæ, or fleas (fig. 64), is not a large one in point of species, but nevertheless manages to attract the attention of mankind. The fleas never have wings, but nature, always compensating, has endowed them with most remarkable leaping ability. The body is compressed, and the segments furnished with rows of bristles, and often some stiff spines. These spines are usually set upon the lower margin of the head and the posterior border of the pronotum, and each series is known as a comb or ctenidium. The antennæ are very short and lie in a groove near the small eyes. The mouth-parts are slender and suited for piercing the skin of the host and sucking up blood. The legs are very bristly, but not very large, and apparently incapable of producing the amazing leap. The larva of a flea is a slender, legless creature occurring under carpets, in cracks, near the nests of animals, etc., and feeds on refuse, dirt, and bits of decaying vegetable matter. When full grown they spin a cocoon within which they transform to the pupa, and later issue as adult fleas. In the past few years one of the rat fleas, *Xenopsylla cheopis*, has been connected with the dissemination of bubonic plague. Fleas may be taken from the host animals and in these animals' nests. All should be collected in vials of alcohol, and mounted in balsam on slides for study.

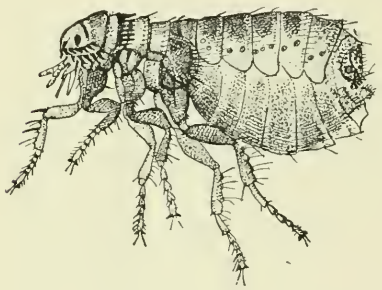

FIG. 64.—A FLEA.

HYMENOPTERA.

This order embraces a great number of insects, many of which are known under the names of bees, wasps, and ants. They have four membranous wings of moderate size, with but few cross veins, and biting mouth-parts. In some cases the mouth is also fitted for sucking or lapping up liquids, but the mandibles are still suited for biting. The body is very compactly put together, and the skin is often very hard, and in many cases the abdomen terminates in an ovipositor or sting. The thorax of most Hymenoptera comprises not only the three parts found in other insects, but also the first abdominal segment. The transformations are complete. The larvæ are usually footless, but those of the sawflies have six true legs and often prolegs which are more numerous than in lepidopterous insects. The Hymenoptera may be divided into suborders as follows:

The *Chalastogastra*, or sawflies (fig. 65), in which the abdomen is not constricted at base to form a petiole, and the first segment is not united to the thorax. The trochanter of the legs (the small joint between coxa and femur) is of two parts or joints. The tip of the

female abdomen shows an ovipositor with pieces having a sawlike edge. The larvæ have three pairs of true legs, and often numerous prolegs. They feed on plants, and some species make galls on willow. There are two families, Tenthredinidæ and Uroceridæ.

The *Parasitica*, which includes an enormous series of species, the larvæ of which live in caterpillars or other insects (see fig. 139). They are therefore very beneficial. These have the abdomen slender at base, forming a pedicel, the first segment connected to the thorax. The trochanters are usually of two pieces. Many are slender insects with fairly long legs, and among them are many minute forms, some so small that one may be crawling across this page unseen by the reader.

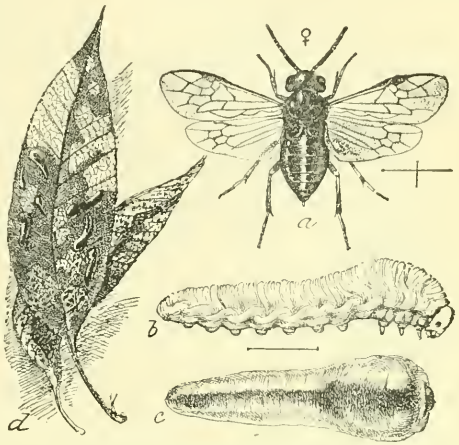

FIG. 65.—A SAWFLY, ERIOCAMPOIDES LIMACINA: *a*, FLY; *b*, *c*, CATERPILLAR OR SLUG; *d*, EATEN LEAVES.

The Proctotrypidæ are the tiniest of these forms; the young usually live in the eggs of other insects. The Chalcididæ (figs. 66, 67) are very numerous, and of variable habits; some live in the seeds of various plants, the jointworms in the stems of grasses, but most are parasitic on other insects. In some cases, although the parent lays but one egg in a caterpillar, several hundred flies may develop from it. The Ichneumonidæ (fig. 68) and Braconidæ (fig. 69) are closely related, and include the largest species. All are parasitic on other insects; many are prettily colored. The females of many species have long, prominent ovipositors, sometimes much longer than the body. Sometimes one of these parasites has a parasite upon it, the latter being called a "hyperparasite."

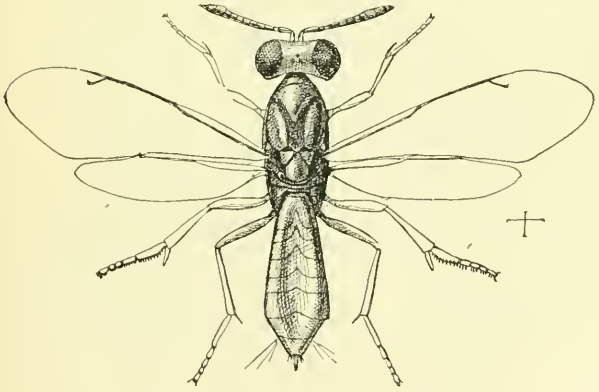

FIG. 66.—A CHALCIS-FLY, EUPELMUS LIMNERIÆ.

The Cynipidæ, or gallflies (fig. 70), are small insects, many making galls upon the leaves and twigs of plants, the larvæ living and developing therein.

The *Heterogyna*, or ants (Formicidæ), include a number of well-known insects whose industry and intelligence have excited the

praise of observers in ancient times. In these insects (fig. 159) there are between the thorax and the main part of the abdomen one or two tiny segments with a knob or lobe above. The trochanters are undivided; the antennæ are often elbowed or geniculate. Ants live in communities of varying size, some of only ten or twenty individuals, others of many thousands. In most cases there are several forms—the winged male, the winged female or mother of the colony, the wingless neuters or workers, and in some cases there are soldiers which have enlarged heads or longer jaws. The larvæ are footless maggots fed and reared by the workers. In some cases they pupate within a silken case. Many kinds of ants can sting.

FIG. 67.—A CHALCIS-FLY, SPILOCHALCIS MARLÆ.

Some ants make slaves of other kinds, the slave working willingly in the new colony. A few species store up seeds for the winter; others keep and protect plant-lice, from which they secure drops of nectar; others grow a sort of mushroom in their nest for food. Sometimes one colony will have a tremendous battle with a neighboring colony. Each ant of a nest can recognize any other member of that

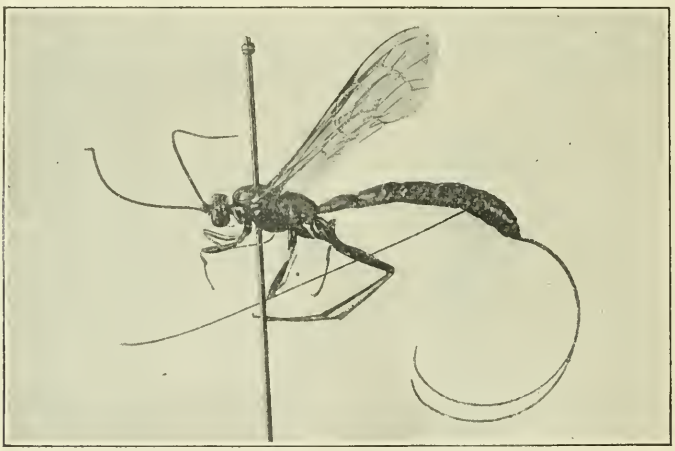

FIG. 68.—AN ICHNEUMON FLY, EPHIALTES IRRITATOR.

nest, no matter how numerous the colony, and they will fight any intruder from another nest. Several kinds of beetles, flies, and mites live in ants nests; these are called "myrmecophiles."

The *Fossores* include the largest and most powerful insects of the order. These insects have a sting, the fore-wings are not folded, and the hairs of the body are not plumose. Most of

them have rather large heads, long legs, and nearly bare body, which is often brightly colored. Some dig holes in the ground in which to rear their young. Others will tunnel in wood, and others prey cuckoo-like upon the other groups. They capture all sorts of insects and spiders, and store them in their nests for the food of the young. Many show much intelligence in preparing their burrows and in capturing, stinging, and storing their prey. Some of these wasps (Mutillidæ) have wingless females (fig. 71). The adults (fig. 140) can frequently be found upon flowers, upon the nectar of which they feed. The mud-dauber wasps (Sphegidæ) (fig. 72) belong to this group.

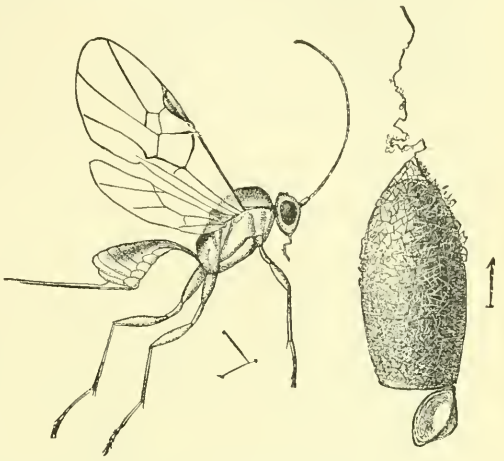

FIG. 69.—A BRACONID FLY, METEORUS HYPHANTRLÆ, AND ITS COCOON.

The *Diploptera* are stinging Hymenoptera in which the fore-wings can be folded longitudinally. The body is usually nearly bare, and the hind tarsi are simple. They are known as wasps. Some are social wasps (Vespidæ) (fig. 73) which make large nests in which to rear their young and which have three forms—the male, female, and worker. Others (Odyneridæ) are called solitary wasps, since they do not form colonies and there is no worker form, each female preparing a cell for her young. The paper nests of the white-faced hornet, one of the Vespids, are common in the woods of the Eastern States. Other species (yellow jackets) build nests in cavities in the ground.

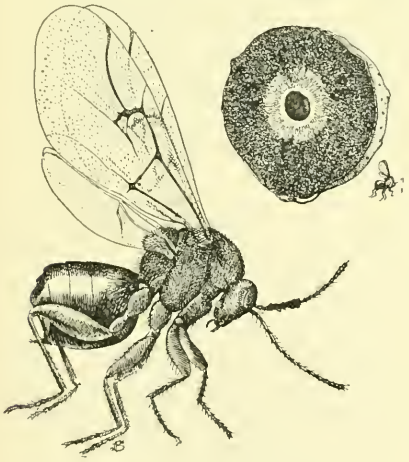

FIG. 70.—A CYNIPS AND ITS GALL.

The *Anthophila* includes the bees (Apidæ), stinging Hymenoptera, which are usually hairy and some of the hairs are plumose. The basal joint of the hind tarsus is elongate, and it and the tibia often fitted to carry pollen. The mouth of bees is provided with a tongue, sometimes quite long, with which to lap or suck nectar from flowers.

The young of bees are reared in cells which are constructed by the mothers. The food given is a mixture of pollen and honey. Some larvæ spin a cocoon, in which they transform; others do not. Quite a number of bees (fig. 74) are parasitic on their more industrious relatives, the adult laying eggs in the nest prepared by another bee, and her egg hatching before that of the rightful owner.

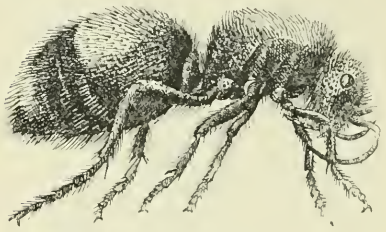

FIG. 71.—A MUTILLID OR STINGING ANT, SPILÆROPHTHALMA OCCIDENTALIS.

The honey bee is social, and there is a worker caste which builds the cells, collects the nectar and pollen, and cares for the young, the female or queen only laying the eggs. The bumble-

FIG. 72.—A FOSSORIAL WASP, SPHEX ICHNEUMONEUS.

bees are also social, and make their nests in the ground; a female that has hibernated starting a new nest each spring. But most bees are solitary; that is, each female makes a nest for herself in the soil, in wood, or under stones. One of these, the leaf-cutter bee (*Megachile*), cuts pieces of rose leaves with which to line her nest in a hollow of soft or rotten wood. Bees are the principal factor in the fertilization of all flowers that have colored petals. Indeed, in some countries where they have no bumblebees they can not raise clover seed until they have imported these bees.

FIG. 73.—THE WHITE-FACED HORNET, VESPA MACULATA. (AFTER SANBORN.)

COLLECTING APPARATUS.

Nets.—The essentials of collecting are a net, a killing bottle, pins, labels, and a box in which to keep the specimens. Practically every entomologist uses an insect net. This consists of a handle, a ring, and to the latter is attached a net. One can find a number of different forms in the catalogues of the dealers. If desired, one can make a very serviceable net for himself. One way is to take two pieces of stout wire, each about 15 to 20 inches long, bend them half circularly (fig. 75, *c*), and at one end make a folding hinge having a check on one side (fig. 75, *b*); the other ends are bent and beaten into two square sockets (fig. 75, *f*), which fit to a nut, soldered into one end of a brass tube (fig. 75, *d*). When so fitted, they may be securely

FIG. 74.—A BEE, EPEOLUS REMIGATUS.

fastened by a large-headed screw (fig. 75, *c*) which fits into the nut sockets. A handle may be cut and fitted into the hollow tube (fig. 75, *d*), which should be several inches long.

A net with entire ring may be made by bending a piece of stout wire into a circle, leaving an inch or so at the end. These ends may be bound together tightly by smaller wire and then tinned by applying a drop of zinc chloride; then hold these ends in a fire or gas jet until red hot, and a few drops of solder placed upon the ends will join them firmly together. A brass tube, or rifle cartridge with end cut off, may be used to hold these ends. The tube should first be tinned with a little zinc chloride; cork up one end of the tube, then fill it with melted tin or soft solder, and insert the ends of the ring. When cold the cork may be removed and a suitable stick inserted.

Another way to make a simple ring is to bend a stout wire into a circle, leaving a few inches at the end, fully one-half inch of the extreme ends again bent as in the figure 76. Near the end of a stick two small holes are made, large enough to hold the bent ends of the wire. These are inserted into the holes, and then the ring is bound tightly to the stick by wire or stout cord; a groove cut in each side of the stick for the reception of the wire will make a better job. A winding mallet (fig. 77) may be used to wind the cord. The cord is wound around both mallet and stick and a turn or two around the handle; then, by turning the mallet around the stick, the cord is gradually wound upon the stick as tightly as the cord will stand. This mallet is useful to bind up a broken handle, if the break is oblique. Another plan of net is shown in figure 78; it is too heavy for anything but beating.

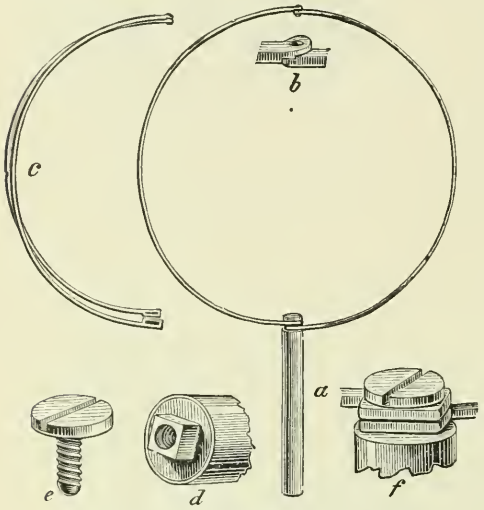

FIG. 75.—A BUTTERFLY NET-FRAME.

The various dealers in entomological supplies have a variety of nets, most of which are cheap and serviceable; one of the most popular is known as the "American" net. It will be best in the end to purchase a net. The size of the net varies with the purpose for which it is to be used. For general sweeping a ring of from 12 to 14 inches is sufficient. A beating net may be larger. For catching butterflies and dragonflies a net of 15 or 18 inches is better, provided this is not of too heavy material, for in catching these insects a rapid stroke is necessary, which is only possible with a light net.

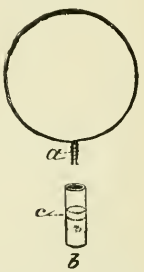

FIG. 76.—THE SANBORN NET-FRAME.

For collecting small insects from flowers, bushes, etc., a midget net, 5 to 7 inches in diameter, is better than a larger net. This should be fitted to a short handle. A very handy one may be made by bending a piece of wire into a circle 5 inches in diameter, leaving an inch or so free at the ends. These may be inserted in the hole of a common spool and a short stick crowded in between them from the opposite end. Such a net may be carried in an ordinary coat pocket and put together in a few moments. Mr. Kearfott, for

micros, uses a piece of spring brass wire, forming a net 6 inches across, leaving the ends straight. A hole is cut through a bamboo stick at the end, and the ends of the wire are inserted. Just before the holes the stick is wrapped tightly with stout cord to prevent splitting. For the net he uses white silk—a very fine-mesh silk veiling.

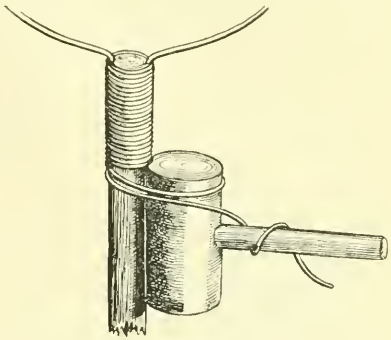

Fig. 77.—The winding mallet.

The handle of the net is of variable length and strength. For beating bushes it is necessary to have a very stout stick, hardly more than 2 feet long. For sweeping, the handle may be lighter and longer, 30 to 32 inches. For butterflies and dragonflies a bamboo handle is very good and may be 3 or 4 feet in length. Longer handles may be useful in special cases, and may be fastened to the ordinary handle. Most dealers make a jointed handle, which is a great convenience in packing, and one-half is about the proper length for beating.

The net may be of various materials. For butterflies a light net is the best; some thin material through which one can see the insect. Some use silk, or a silk gauze; some a material called "tarletan;"

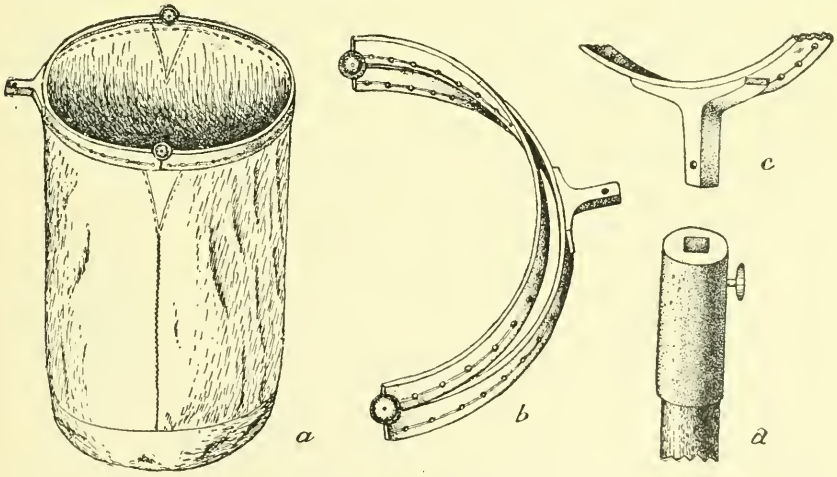

Fig. 78.—The Deyrolle sweeping net: *a*, Net entire; *b*, frame; *c*, *d*, attachment of frame and handle.

others prefer "bretonne net." What is known as cheese cloth, bobinet, or even mosquito netting does well for the beginner. For micro-lepidoptera, especially for a small net, a fine quality of silk is best; white china silk lining is good. Particularly in small nets one should

use material which has not the slightest tendency to stiffen or kink. Some collectors use green or gray nets for Lepidoptera, but for general purposes a white net is the best. In length the net should be twice its diameter and should taper to the bottom. A sweeping net should be of stouter material, and where fastened upon the ring is sewed on to stout twill muslin. Some collectors fasten the net to small rings upon the main ring, as in figure 79. This saves the net from wearing out, as it is very apt to do when used much in dense brush. For beating a still stouter net is required; heavy twill muslin is good material.

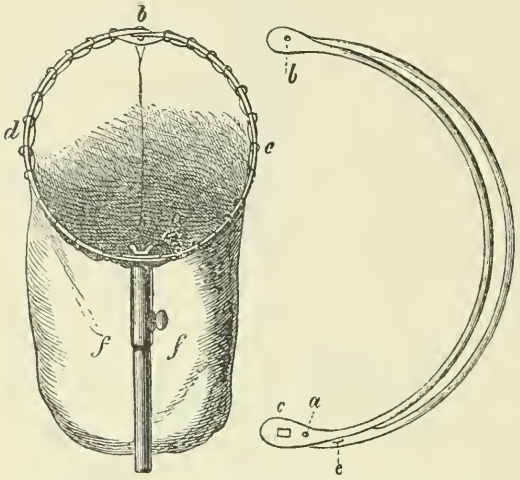

FIG. 79.—A BEATING NET, OPENED AND ATTACHED TO HANDLE, WITH FRAME OF SAME FOLDED. (AFTER KIESENWETTER.)

For aquatic collecting an open net (fig. 80) is preferable. A mesh of one-eighth inch is plenty large enough, as a larger mesh will permit the escape of many small insects. The water net should not be as long as the other kinds, and indeed may be very short (fig. 80). The top of the net may be covered by a coarse wire netting, either flat or conical, which will prevent plants and large débris from entering the net. For aquatic collecting, however, a dip net of wire mesh (fig. 81) is very useful, especially in collecting mosquito larvæ and other insects swimming in the water. With its sharp edge one may scrape insects from submerged stones. For insects in mud, among leaves on the bottom, among weedy marges, etc., a dragnet or a sieve net (fig. 82) is the right thing.

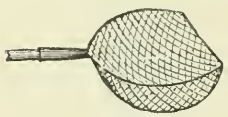

FIG. 80.—A WATER NET. (AFTER PACKARD.)

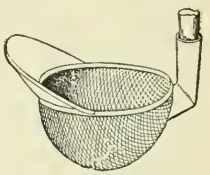

FIG. 81.—A SMALL WATER DIP NET.

Some collectors, particularly in Europe, have advocated the use of a scissors or forceps net (fig. 83) for small insects, but this is rarely used by American collectors. Mr. Conradi attaches to the forceps net, in the center of one of the nets, a tin tube one-half inch long, with outer end corked. When he desires to remove the insect the cork is taken out and the tube fitted into a cyanide bottle. A rattan net, made by some dealers, is very light and useful in capturing butterflies and other insects in flight.

What are known as "Simplex" nets are advocated by some entomologists. The ring is made of a piece of flat steel, which readily coils up, and may thus be carried in the coat pocket. The ends of the steel strip are fastened to the stick by various devices; usually by a ring or brass ferrule passing over them. These nets are, however, not

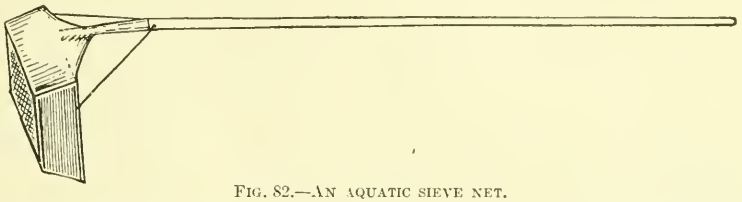

FIG. 82.—AN AQUATIC SIEVE NET.

as steady in use as one with stiff wire, but will last a long time and are cheap. They can be obtained in various sizes and with nets of several kinds.

Mr. Viereck has used with success a net made as follows: An ordinary insect net with an open bottom which has two rings close together. To this bottom is fastened a small bag with drawstring to close it tightly between the two bottom rings. The insects swept, fall into the bottom bag, which may be removed and placed in a cyanide jar. Another small bag is put on the net, and one can go on collecting while the first lot of insects is being killed by the cyanide. This apparatus will be especially useful in collecting Homoptera.

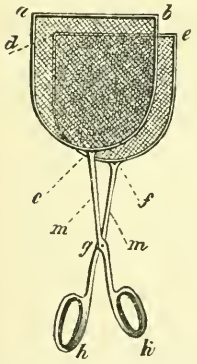

FIG. 83.—A FORCEPS NET. (AFTER KIESENWETTER.)

The umbrella.—An umbrella can be used to great advantage in collecting insects from foliage and dead twigs. If the handle is jointed, as shown in the illustration (fig. 84), it is more convenient. The inverted umbrella is held in the left hand under the branch, and with a stick in the right hand one can suddenly jar the branch, so that the insects clinging to the leaves or twig will be dislodged and fall into the umbrella. The branches should be jarred vertically and not horizontally, else some insects will be thrown beyond the umbrella. A curved handle to the umbrella is best, as with it one may often reach and pull down a bough, while a suitable stick is not always quickly found. A small cyanide vial with a quill through the cork is the best instrument to take insects from the umbrella.

A substitute for the umbrella, and in many cases better than it, is the beating cloth. It consists of a piece of common unbleached cotton cloth, 1 yard square, to each corner of which a loop of stout twine is sewed, or a corner turned over. Upon reaching the woods, two straight sticks, each about 5 feet in length, and not too heavy, but

also not so small as to break or bend too easily, are cut from a convenient bush. The sticks are placed crosswise over the cloth and fastened to the loops at the four ends. This is easily and quickly done by making sliding loops of the simple loops. The cloth is thus kept spread out between the sticks. To the center of the sticks another stick may be fastened, so as to hold the cloth out under the branch.

The sieve.—This consists of a wire sieve, to which is secured a cylindrical bag or net (fig. 85). Masses of fallen leaves may be taken up and dumped into the bag, and when shaken the insects will fall through upon a white cloth or stiff paper placed on the ground for this purpose. A good size for the sieve is a foot in diameter. The meshes should not be over one-fourth inch, and for sifting some materials one-eighth inch. In using the sieve one must not shake it too long before examining the cloth, else there will be so much débris as to obscure the insects. Many insects, when disturbed in this way, will play "possum," and it is therefore necesary to leave the cloth a few moments to give these coy insects a chance to start in motion. Two cloths laid a few feet apart and used alternately will effect this purpose. In cold weather one may so place and incline the cloth or paper that the sun will strike and warm the dormant insects into activity.

FIG. 84.—THE UMBRELLA AND ITS MODE OF USE. (AFTER KIESENWETTER.)

Besides dead leaves, the sieve may be used to get the insect forms from moss, ants' nests, old decayed trees, etc. One will be surprised at the great number of forms that may be gathered by the judicious use of the sieve. Many larvæ may be found, and a vial with a toothpick wet with glycerin will be handy to pick up the minute springtails and other forms. In winter one may gather likely material

in sacks and carry it home, there to sift it at leisure. The larger amount of material may be usually secured from wet localities, but other forms will be found in dry places. Unpromisisng spots, though not furnishing so many insects, may often give something not elsewhere obtainable.

Various other methods have been devised to obtain the small insects found in fallen leaves, moss, etc. Hot water funnels are supplied by several dealers, and a "Photo Klector" is sometimes used in Europe. The latter is a flat triangular box with glass at one corner and a hole near by. To this hole is attached a glass jar. A rack with a sieve is placed inside, upon which is put the moss, leaves, etc. The insects crawl out, fall through the sieve, and walk along the bottom to the light in the glass corner, then fall through the hole into the glass jar. A more elaborate apparatus is the Berlese collecting cage (fig. 86), described by Doctor Howard as follows:

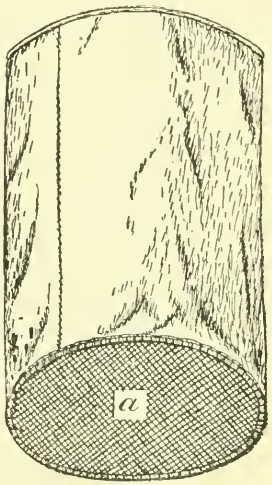

FIG. 85.—A SIEVE: *a*, WIRE NETTING.

While visiting the laboratory of Prof. Antonio Berlese in Florence, in June last, I was greatly interested in an apparatus which he has prepared for collecting small insects and other arthropods very rapidly and in very great numbers, and which it seemed to me obviated in large measure the laborious process known to entomologists as "sifting." He showed me the apparatus practically in operation, and showed me, further, large numbers of vials filled with Thysanura, Myriapoda, Acarina, and the like, which in number and variety afforded a perfect revelation to me. Since returning to this country I have had one of the smaller styles of the apparatus made, and have tested it during the month of December with leaves and rubbish collected on the grounds of the Department of Agriculture and with very considerable success; so much so, in fact, that I wish to bring the apparatus to the attention of English-speaking entomologists. No doubt had I used leaves or top soil of old and long undisturbed wooded regions the results achieved would have been vastly greater than they have with the material tested; but even this, as just stated, has been very satisfactory. Professor Berlese's description and statement concerning results was published in Redia, Vol. II, No. 1, shortly after my visit, and his article, very freely translated, is as follows:

Within this last year I have devised an apparatus which is very simple and very effective, with which I collect in great numbers and without fatigue, the small Arthropods as well as insects of all the following orders: Myriapoda, Symphyla, Pauropoda, Chelifera, and Arachnida, and especially Acarida, however small, without any danger of being able to escape. Of the Collembola, which are so difficult to collect because they spring, I have taken a very great number.

All those living creatures which are found to be present in the mosses, among the dead leaves under the trees, in decaying wood, in humus, in decomposing substances, etc., are collected in a tube containing alcohol, which is attached to the apparatus under discussion, and on the part of the naturalist there is no further trouble than to separate them and study them. The apparatus consists of a large funnel which slides into a glass tube containing alcohol and this funnel is surrounded by water heated to

60° to 100°. On top of the funnel there is placed a sort of square tray of metallic network (a sieve) upon which is placed the material to be examined, and this material should naturally be sufficiently humid to restrain the living insects from escaping. Whether the material in the tray, passing gradually (although rapidly enough) through and losing some of its moisture causes the insects to fall to the bottom, or whether these are attracted by the heat beneath, it is certain that they all try to reach the metallic net and there they pass through, falling into the metallic funnel.

But the walls of the funnel, thanks to the water surrounding them, are so warm that the insects can not remain, and they fall, rolling downward until they enter the tube containing alcohol, in which only a very small quantity of detritus is collected.

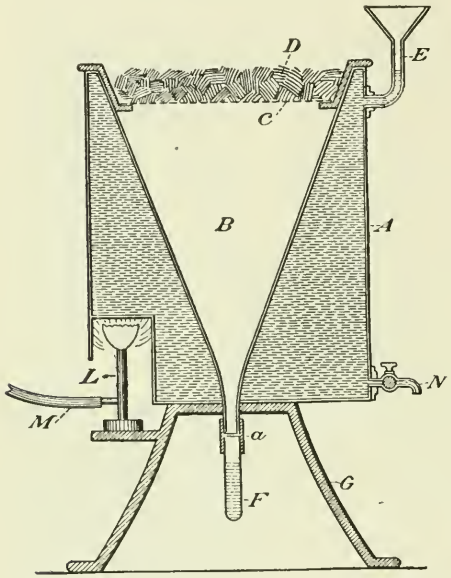

FIG. 86.—THE BERLESE COLLECTING TRAP: *A*, EXTERIOR RECEPTACLE CONTAINING WATER; *B*, INTERIOR FUNNEL; *C*, VESSEL HAVING THE BOTTOM OF METALLIC NETWORK; *D*, SUBSTANCE FOR EXAMINATION; *E*, FUNNEL FOR INTRODUCING THE WATER; *F*, SMALL GLASS TUBE CONTAINING ALCOHOL, WHERE THE INSECTS ARE COLLECTED, THIS BEING CONNECTED TO THE APEX OF THE FUNNEL BY A SHORT TUBE (*a*) OF INDIA RUBBER; *G*, FEET SUPPORTING THE APPARATUS; *L*, LAMP FOR HEATING; *M*, INDIA RUBBER TUBE FOR CARRYING OFF THE GAS; *N*, FAUCET FOR DISCHARGE.

It is necessary, however, not to shake or stir the apparatus or the material during this operation, to avoid the falling of too much detritus together with the insects.

The diameter of the funnel should be about a half meter, and the tray itself should be movable in order that it may be refilled with the material when separated from the funnel.

I have used to great advantage a small apparatus of this style (the funnel being only 30 centimeters in diameter) during the last year, and have thus discovered several new species of Italian Acarida, illustrated in this journal, while I have collected an enormous quantity of other small arthropods, especially of Collembola, Symphyla, Pauropoda, etc.

These, especially the Collembola, and also the Thysanura, all remain on the surface of the alcohol, not becoming submerged, while the other insects all fall to the bottom of the tube.

Thus, it is easy to collect the said Collembola with a brush from the surface of the alcohol without further disturbance.

After the excellent results secured from the small apparatus referred to, I had another, much larger, constructed which has been operated since November.

It is composed of a case of wood, the interior of which is covered with lead, and has a capacity of 6 hectoliters, and contains four large funnels in square sections, the sides of which are 50 centimeters. Thus I have an extent of 1 square meter upon which to arrange the material for examination, and I can place four different kinds of material from four different localities on these sieves.

The water is about 3 hectoliters and is kept at 60° or 70°, and for some hours the temperature is maintained by means of a large gas heater.

This heater, which serves me well also for heating the room in which it is placed, consumes about 3 cubic meters of gas per day, which proves that, with an expense of about 1 lira, I daily obtain, without any trouble, a greater number of small insects

than ten persons, with all the fatigue and patience possible, would be able to collect in the same length of time, and, besides, I have the assurance that scarcely an individual insect has escaped. (Entomological News, 1906, p. 49.)

Chisel, trowel, and hatchet.—These tools, of which a variety may be obtained at any hardware store, are useful in digging insects or larvæ from the ground, examining ants' nests, for loosening the bark of trees, and for cutting into trees to obtain wood-boring species. However, a good pocket knife can be used, though not so successfully, for this purpose.

Tin boxes and pill boxes.—One should, for general collecting or for gathering larvæ, take into the field a number of tin boxes and pill boxes. The tin boxes can be used for caterpillars and other larvæ, and a few leaves of the food plant may be inclosed with them. Coleopterous larvæ from rotting wood should be placed in boxes filled with the decayed wood, so that they will not shake around and injure themselves. Galls and leaves with mining insects should also be gathered in these tin boxes. Some dealers have for sale tin boxes especially made for collecting larvæ. Aquatic larvæ should be packed in tin boxes with wet moss, for they will die if carried long in a vial filled with water.

Lights and other traps.—Many insects can be obtained by various traps. These are principally lights and "sugaring," and are employed to attract night-flying insects. Many ground-loving species, however, can be trapped under pieces of bark, placed in likely situations, such as at the edge of meadows, cultivated fields, dense woods, along streams, etc. Particularly in the autumn, when many insects are seeking winter quarters, it will be found profitable to put out these traps. Dead animals will serve to attract necrophagous insects. Pieces of cloth may be wrapped around trees and examined from time to time, and will be found to harbor many insects. Tin cans or bottles sunk in the earth with the tops even with the ground will trap many larvæ and other insects. More elaborate traps may be readily made; for example, a large tin funnel with cyanide jar at end, and a central plate in top for a dead mouse, bird, or other carrion. Such a trap, buried in the ground with top even with the surface, will attract and capture quantities of beetles.

The use of lights in attracting moths and other insects has been followed by all entomologists, and a great variety of these lamps is obtainable from dealers. A strong portable lantern, hung so as to throw its light upon a white sheet, the latter supported by a couple of sticks, or suspended from a branch, will serve to attract a variety of nocturnal insects, and has the great advantage of being carried and set up anywhere in the woods. Many insects, upon reaching the light, have the habit of flying upward. If the white cloth is stretched upon a frame and set obliquely above the lantern many

insects will alight upon it. Other insects, especially beetles, have the tendency to fly at the light and then fall. A tapering bag placed below the light, with the bottom opening into a cyanide jar, will secure these.

Many collectors have devised various forms of traps to capture the insects that come to the light. One (fig. 87) is by Professor Gillette. It is in three parts, all of bright tin. The funnel is 22 inches in diameter, the tube 2½ inches. This tube fits into the top of the reservoir below; the latter has a removable bottom. The reservoir is nearly filled with loose excelsior. The bottom is removed, and in its place is put a wide-mouthed glass bottle half full of cyanide. The cyanide should be slightly moistened and a piece of paper or wire mesh placed over it. The apparatus can be suspended in a tree or placed on a stand, and a large lantern hung over the top of the funnel so that the blaze will be just above the top of the funnel. It is well, on good nights, to empty the reservoir before leaving it for the night. This is done by taking out the excelsior and insects, placing them in cyanide bottles, and putting new excelsior in the reservoir.

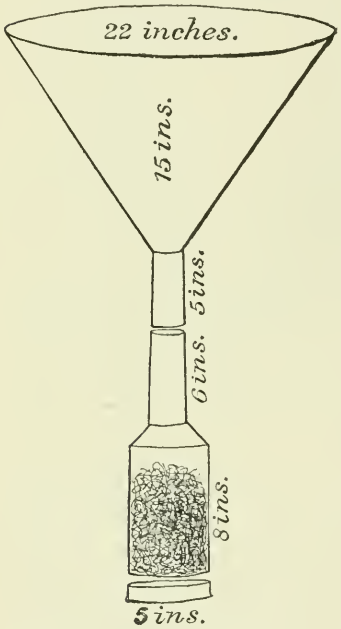

FIG. 87.—THE GILLETTE TRAP LIGHT.

The apparatus used by Mr. Morse is described by Mr. Smith as follows: It consists of a box of wood, having glass on each of its four sides and a cover with arrangement for outlet of heat and smoke similar to old-style street lanterns. At the bottom are holes for the ingress of air. The box is large enough to contain an ordinary kerosene lamp with chimney and is supported over a wooden box about 18 inches square, which in turn contains a zinc pan about 2 inches deep and as large as will go into the box. At the base of each pane of glass is a slot the whole width of the glass and about 1 inch wide, which opens directly into the pan below. The pan is filled about half full with water and then about a pint of kerosene is poured on top. The moth strikes the glass and falls through the slot and is killed by the oil. In the morning he takes a good-sized pasteboard box, in the bottom of which is about a dozen thicknesses of old newspaper and with a slender pair of forceps picks the moths out by the legs and lays them on the paper. They are left there for about two hours to get rid of most of the oil and water; then

put in a large shallow pan of gasoline and covered with a pane of glass and left for some hours, frequently over night. Then pick them out and lay on blotting paper and the gasoline soon evaporates, leaving the moths clean and bright as though never wet.

Another light trap is shown in the accompanying illustration (fig. 88). It consists of a box larger in front than behind and attached behind to a lantern. Within the box are three panes of glass, placed obliquely (two will do). The moth flying against the outer pane rises and enters, then falls and enters beneath the second glass; as it hits the side of the lantern it falls into the cyanide jar beneath. In case it does not fall at once, it does not readily escape owing to the position of the glass panes. The back of the lamp box should be hinged with cloth so that the light may be readily inserted and removed. The cyanide jar can be attached by cloth or screwed

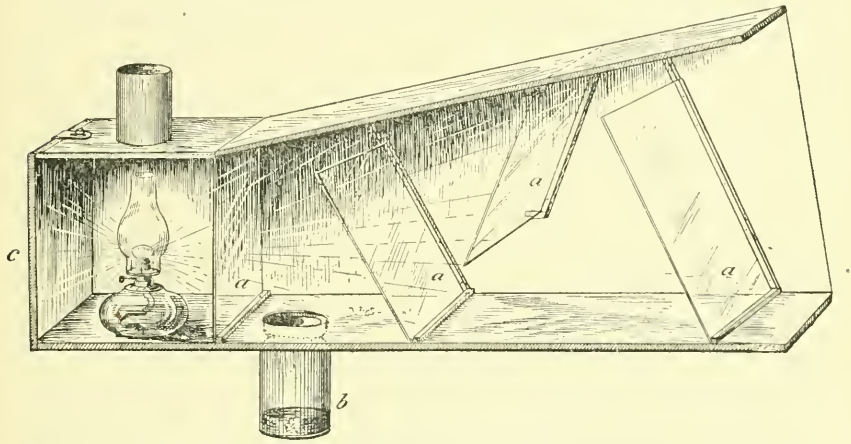

FIG. 88.—THE BROOKLYN LIGHT TRAP.

in. The great advantage of these light traps is that they work over night. It is best to paint the inside of these traps white and the outside black or green. A pint Mason jar may be used for the cyanide jar, the top with center cut out fastened to trap, and jar screwed up into it. A bottomless tomato can may be used for the smoke vent, and the panes of glass can be held in place by strips of upturned tin or by nails. Anyone who desires to form a collection of moths will find some form of light trap indispensable.

Sugaring.—Many insects, especially moths, have a fondness for sweets. Entomologists have taken advantage of this by smearing some sweet mixture upon the trunks of trees. This is known as sugaring. The mixture should be placed on the trees at twilight, and upon a number of trees. If there is a breeze the sugar should be placed on the leeward side of the trees. Then as darkness comes on one may go from tree to tree, and by the aid of a lantern (a dark

lantern is usually preferred) secure the moths or other insects. A mixture of sugar and vinegar, or sugar and molasses, to which is often added beer or some other alcoholic liquor, is most favored by collectors. A mixture of sugar and rotten apples, or other decaying fruit, is extremely good. Warm, moist, cloudy nights are the best for sugaring, but one can not always be sure of a good catch, as insects sometimes come when least expected, and seemingly most favorable conditions are often unprofitable. One should take several cyanide bottles upon a sugaring trip, so that it will not be necessary to put many insects in one bottle. A net can be used to take those that fly around, and if the light is thrown upon the net many moths will rest upon it.

Some prefer to have one or two chloroform bottles with which to capture the specimens, and then when they have become quiet put them in the cyanide jar. Mr. Caudell devised a cloth funnel for catching quantities of moths. The bottom of the funnel was fastened by a rubber band to a large cyanide jar; the top had a wire or steel ring, but open on one side; this opening enables the collector to fit the top of the funnel to a tree or around a corner. Approaching a bevy of moths at the sugar the edge of the funnel was applied closely to the bark beneath them, and a puff would send the moths falling through the funnel into the cyanide jar, which is then corked, and another one fastened to the funnel for the next tree. A similar apparatus is used abroad.

One can so arrange his route that the sugared trees are in a circle, and thus visit each regularly. It will be found that some moths come early and others only late at night. Frequently one can find some moths, like Catocalas, at the sugar next day. A few collectors have used baked apples to attract moths, and others string rotten apples dipped in sugar between trees.

Forceps or tweezers.—Small metal forceps (fig. 89) with fine points are used by nearly all entomologists in picking up insects. These are made both with curved and straight points, and can be purchased from dealers for a small amount. By practice with the forceps, one can handle the most delicate and fragile insects without injuring them. For handling the pinned specimens a stouter form of forceps, known as pinning forceps, is used. These are shown in figure 90. Most people become accustomed to a certain style and can use it better than any other; a lighter pair is preferred by many.

Brushes, belts, bags.—Several small brushes are useful to the entomologist. They may be used to clean an insect, and by moistening the tip to pick up small and delicate specimens. Many collectors who go into the field to gather insects of one group are often able to carry all their utensils (net, killing bottle, tubes, forceps, boxes, or folded papers) in the pockets of an ordinary coat. Others have

coats especially made for the purpose of some very stout and durable material with deep pockets, so that in stooping nothing will fall out of them. Some carry a belt similar to a cartridge belt around

FIG. 89.—THE COLLECTING FORCEPS.

the waist. Small pockets are sewed on to this to hold tubes or vials (fig. 91). Most entomologists, however, carry a haversack of waterproof cloth or leather, with several compartments to hold vials,

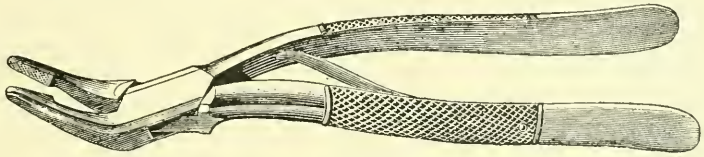

FIG. 90.—A PINNING FORCEPS.

empty boxes, killing bottles of several sizes, and a small box in which to pin delicate insects shortly after capture. This haversack or bag is slung across the shoulders by means of a strap.

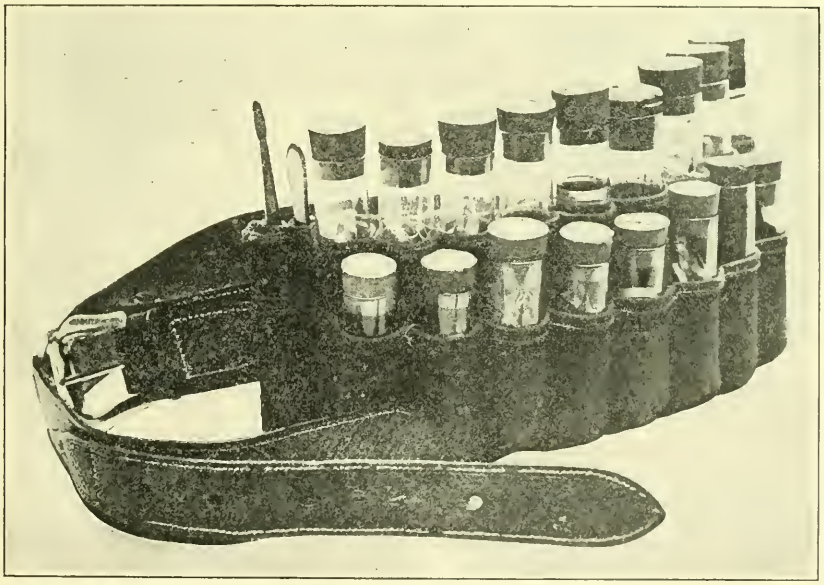

FIG. 91.—A BELT FOR VIALS.

The lens and microscope.—A hand lens or pocket magnifier is sold by all entomological dealers and by firms dealing in microscopic supplies. One should use some care in this matter, as a poor lens,

especially if of high power, is apt to injure the eyesight. A half-inch lens will be found as useful as any for most insect work. For Lepidoptera a three-fourths or an inch lens will be useful. For the minute insects a one-fourth inch lens is used by many, but a compound microscope is better for the eyes.

An ordinary lens may sometimes be used to advantage in the field by fitting a piece of cork in the handle, and sticking an insect pin obliquely through it so that the point of the pin is at the focal distance of the lens. A strong reading glass is very useful in looking over boxes of specimens.

FIG. 92.—A CYANIDE BOTTLE WITH PAPER STRIPS TO GIVE SUPPORT TO THE INSECTS.

Dissecting microscopes sold by most dealers are of great value and should be more generally used. The compound microscope is necessary to all who endeavor to do some original work with small insects, or to study the anatomy of insects. There are various firms, a list of which is given in the back of this article, that supply these, as well as all accessories, slides, cover glasses, stains, etc. In these matters one must consult his means, but a useful instrument can be obtained for about $50. For studying the exterior structure of insects, it is not necessary to have much apparatus known as the substage, nor more than one or two eyepieces and objectives. Many microscopes are so fitted that one can revolve the mirror above the stage and reflect light from above upon the insect. For examining an insect it is well to fasten a cork to a glass slide and stick the pin in this cork. The cork may be fastened to the slide as follows: Drop a little Canada balsam on the slide, heat it to almost boiling from beneath, and then put the cork in it. When cold, the cork will be held firmly to the slide.

KILLING INSECTS.

A bottle or jar (fig. 92) containing a poison is used by all entomologists to kill their captures. The poison ordinarily used is potassium cyanide, a hard, white substance, which can be purchased at drug stores. There are various ways of preparing a bottle or vial. The usual way is to place the cyanide, broken up into a few lumps,

in the bottom of the bottle, covering it with a little dry plaster of Paris; then mix some plaster of Paris with water, just sufficient so that it is about as thick as can be stirred; then pour it over the cyanide so as to cover it to a depth of about 5 mm. (one-fourth inch). The bottle is then left open for a couple of hours until the plaster is dry. After this the bottle should always be kept corked, so that the fumes of the cyanide are strong enough to kill the insects in a few moments. It is always well to place a few strips of blotting paper in the bottle to absorb any moisture and to prevent the insects from shaking against one another. A bottle well made should last several years.

FIG. 93.—A POCKET CYANIDE TUBE.

Great care should be exercised in handling potassium cyanide, as it is a deadly poison, and if any is left over after one has prepared all the bottles desired it should be buried deeply in the ground. For small tubes a lump of cyanide may be wrapped in paper till it fits tightly in the bottom of the tube (fig. 93). Some prefer to fasten the paper containing the cyanide to the inside of the cork. In collecting a variety of insects one should have at hand a number of cyanide bottles, some large ones and others of a smaller size, so that the insects of each size may be kept together. Very delicate insects should be put in a cyanide bottle with a great deal of paper and no larger insects with them. Similarly, long-legged species should be kept by themselves.

Some claim that a few drops of tartaric acid added to the cyanide will make a stronger poison. In dry regions the cyanide does not act so quickly, and a few drops of water, or tartaric acid, or even soda water, will increase its effectiveness. Others put sawdust over the lumps of cyanide and then a layer of plaster of Paris. Mr. Ricksecker advises putting the cyanide into a short tube, closed up with blotting paper, and insert the tube tightly in a hole through the stopper or cork of the jar, the tube opening inside of the jar. By this method one can keep the jar clean, washing it out when desired, and one can recharge the tube easily, while the same stopper and charged tube can be used on other bottles of the same size. Mr. Wenzel has used small tubes open at each end, and charged in the middle with cyanide, for collecting minute insects.

Some entomologists for minute species, especially for securing insects from an umbrella, use a cork stopper through which is inserted

a goose quill with the outer end cut obliquely (fig. 94). The minute insects may be scooped up with the end of the quill and fall through it into the bottle. If the cyanide jar is well made, most insects will die in a few moments. Those with bright yellow colors should not be left in any longer than necessary, as the cyanide vapor turns the yellow red.

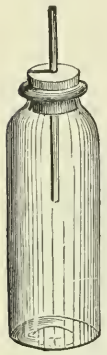

FIG. 94.—A BOTTLE WITH TUBE THROUGH THE STOPPER.

All delicate insects and those with fragile legs should be pinned as soon after their death as possible. Too much importance can not be placed on this matter, as delicate insects are rarely properly prepared, and the main difficulty is that they have been left too long in the poison bottle. Therefore, after one has collected a while, he should sit down in some shady nook and pin the more fragile species. Most insects, however, may remain in the bottle for four or five hours.

Various other poisons have been used to kill insects. English entomologists advocated the use of crushed laurel leaves. These, however, have not a very strong odor. Others prick the insect with a needle or pin dipped in a saturated solution of oxalic acid, after being quieted with chloroform. Many entomologists have used chloroform or ether to kill insects. Chloroform, however, is apt to stiffen the muscles of insects, so that it is not easy to spread their wings. When insects are collected in pill boxes, a drop of chloroform on the cover will soak through and kill the insect inside. Some take into the field a bottle of chloroform (fig. 95), with a brush attached to the stopper. Touching the side of the thorax of the insect with a moist brush will be sufficient to quiet it. Chloroform is so volatile that if enough is not used at first to kill the insect it will soon revive and damage itself in its struggles.

FIG. 95.—A CHLOROFORM BOTTLE WITH BRUSH.

Chloroform may be used to advantage in collecting small insects that are very active in flight, particularly when they rest on the under surface of leaves. A wad of cotton is placed in the bottom of a tube, a few drops of chloroform poured upon it, and then a piece of blotting paper and some fine strips of loose paper placed over the cotton. The tube is brought stealthily up under the insect which, instantly overcome by the strong chloroform vapor, drops into the tube. Thus, one after another may be taken in rapid succession. Such tubes will last only a day or two. A piece of rubber soaked in chloroform will retain the odor for a long time. If the insects are to be pinned, it should be done shortly after they are dead, else they will be too stiff and dry.

Alcohol may be used to capture many wingless insects, such as springtails, myriapods, spiders, larvæ, etc., but adult insects should not be collected in it unless nothing better can be secured to kill them. Even for larvæ it is better to bring them home in tin boxes and kill and prepare them in other ways. Alcohol should not be used at full strength, but about 70 per cent is sufficient for most purposes. A little glycerin in the alcohol is an advantage, since if the bottle cracks, or the alcohol evaporates, the glycerin will keep the specimens moist for a long time. It is claimed by some that specimens killed in alcohol are less liable to verdigris, but the use of black pins obviates this danger.

Very large insects may be killed by injecting into their thorax a little kerosene; some have used benzine or gasoline to kill Lepidoptera in the field, squirting it upon the specimen by means of a druggist's dropping tube. Other collectors have used creosote for killing specimens. This, however, will not last more than a few days. Some entomologists have used ammonia for killing microlepidoptera, but it is liable to change some of the delicate colors. All things considered, the use of the cyanide jar is far superior to other methods.

PINNING INSECTS.

Entomologists mount their insects on pins especially made for the purpose. These are more slender and longer than the ordinary pin, and can be bought from all dealers in entomological supplies. As they are now comparatively cheap, all beginners should use them. The price averages about $1 a thousand; many are cheaper. They are made both bright and japanned or black. Some are of steel, and these are not as flexible but keep the point well.

These pins are made in different sizes or numbers, from 000, the most slender, up to No. 8, the thickest. The sizes below No. 1 are usually too small for satisfactory use, as they will not readily enter cork. They are useful, however, in making elbow pins, as explained later. Likewise the pins over No. 4 in size are too large for most insects, and should only be used for insects of extraordinary size. The best size for general use is a No. 2; for smaller insects a No. 1, and for larger, a No. 3. Many lepidopterists use a No. 3 for most specimens and No. 4 for larger forms. Some orthopterists use a No. 4 for most species. However, the No. 3 will carry well an insect of almost any size, and the use of larger pins is apt to result in destroying too much of the thorax. A No. 2 is best for beetles, Hymenoptera, Hemiptera, and flies; a No. 3 for the larger species, and a No. 1 for small forms. Many coleopterists, however, prefer to mount on points all beetles too small for a No. 2 pin.

Each entomologist has a different opinion as to the limits of use of each size, but the general tendency is that Nos. 1, 2, and 3 will cover

almost all requirements except for minute insects. In length these pins vary from 34 mm. to 40 mm. The latter length is rarely recommended. Most collectors prefer a 34 mm. or 35 mm. (1⅜ inches) for all insects except Lepidoptera, Orthoptera, and Neuroptera, for which 37 mm. or 38 mm. (1½ inches) is recommended. Some Diptera (Asilidæ) and Hymenoptera (Ichneumonidæ) should have a 37 mm. pin.

It would be very advantageous if collectors generally would agree on certain lengths, as it would make our collections more uniform, especially where there is much exchanging of specimens.

These pins are mostly made in Germany, and are known as Klaeger, Karlsbader, Schleuter, etc., but several of the American dealers now make a pin of their own very similar to the foreign pins, and some claim of better quality. The black or japanned pins should be used for pinning most insects, while the bright or white pins may be used for points and all double mounts. The bright pins are apt to verdigris—that is, produce a green substance near the insect which will eventually rot the pin as well as mar the appearance of the insect.

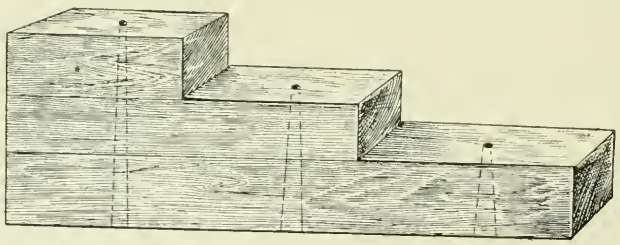

FIG. 96.—A PINNING BLOCK.

There are, however, a few groups of insects that do not verdigris, and for these bright pins are as good as black. Many aquatic insects and those whose larvæ feed in wood are more apt to verdigris than other forms.

The English use shorter pins, but these are not in use now in the United States. Nickel pins are also obtainable from dealers. For small insects many entomologists use very short and slender pins, about 14 mm. long, without heads, known as "minutien nadeln," or "micro-pins." Sometimes fine silver wire is used for this purpose. It is handy to keep the pins in a pin tray or box.

Insects should be pinned as soon as possible after they are dead; the evening after collecting or the next day. Even specimens collected in alcohol should be attended to without unnecessary delay. Many fragile insects should be pinned in the field in a box taken along for that purpose. It looks better to have the insects all at the same height on the pins. For this purpose a pinning block is very useful. One can be made by examining the figure (fig. 96), three blocks with

three holes, each going to the bottom. The upper hole can be used to fix the height of points, the next to fix height of label, and the third to fix height of specimen by inverting it and pushing the insect down to block. Fully one-fourth the length of the pin should extend above the insect (fig. 97). Some entomologists use brass blocks with a minute hole through them for the purpose of gauging the height of the specimen.

The insects should be dumped from the collecting jar upon some soft substance, as blotting paper, cloth, or a folded handkerchief. If soiled, they may be cleaned by a soft, dry brush; or, if beetles with earth attached, they may be washed in ether or benzine. With pinning, as other matters, practice makes perfect, and the beginner should use much care in learning to push the pin through the insect without injuring the parts, splitting elytra, or pushing out a leg. Beetles should be pinned through the right elytron (fig. 97), about one-fourth the distance from the base; most other insects, as Lepidoptera, Hymenoptera, Diptera, Orthoptera, and Neuroptera, through the middle of the mesothorax. In some groups, however, it is preferable to put the pin a little to the right of the center. The Hemiptera are commonly pinned through the scutellum. Many, however, are better pinned through the right wing near the base. The best way is to hold the specimen between the thumb and forefinger of the left hand and insert the pin with the right hand, so that the abdomen will be slightly depressed. Then the pinning block may be used to push the specimen up the pin, but the lapel of one's coat is about as handy as anything. Formerly many spread the legs of the insect. This is not considered advisable, but if they are folded up close they should be pulled out so that each part may be examined with a lens. The antennæ, if long, should be applied backward and near the insect, not sticking out at varying angles. When one captures a pair of insects in the act of mating it is useful to put them both on the same pin, the male above the female.

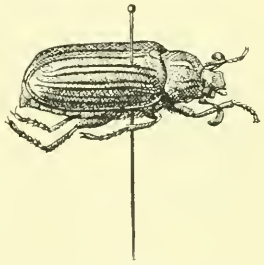

FIG. 97.—A BEETLE PINNED.

In mounting small insects the micro-pins are largely used, especially for Lepidoptera, Neuroptera, and Diptera, and even small Hemiptera. With Hymenoptera and Coleoptera they are not advisable. There are several ways of using these micro-pins in double mounts, as may be seen from the accompanying figure (fig. 98). The most popular way is figure 98, *b*, the micro-pin inserted in one end of a piece of cork and the ordinary pin stuck through the other end of the cork. These cork strips should be narrow, not longer than necessary, and are best cut with a razor. If the sheet of cork is covered with white paper, the strips make a neater appearance. Some have advocated the use of

the pith of corn or yucca. The latter, if not well dried, will rot the pin, and with either material the micro-pin is not held as firmly as with cork. Some use blotting paper instead of cork strips, but this is apt to split. Others have recommended felt; a piece taken from an old felt hat, covered each side with white paper, and then cut into strips. Others have used strips from certain hard fungi.

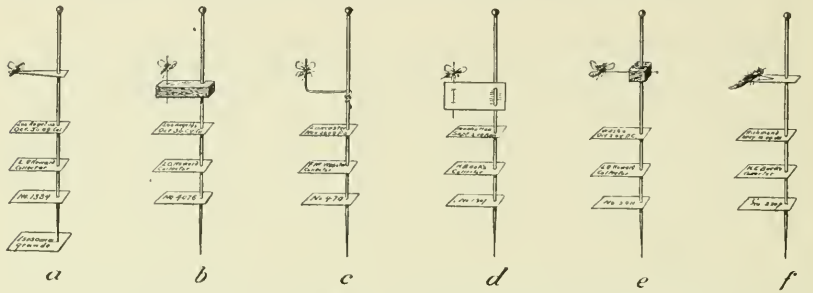

FIG. 98.—MICRO-PIN MOUNTS, OR DOUBLE MOUNTS: *a*, WITH A POINT; *b*, MICRO-PIN IN CORK; *c*, ELBOW PIN; *d*, MICRO-PIN IN PAPER; *e*, MICRO-PIN IN SIDE; *f*, DOUBLE POINT.

A neat way of preparing micro-Diptera as well as some other forms where one does not wish to mar the dorsum of the thorax is shown in figure 98,*e*. The micro-pin is pushed through a small square of cork, and then into the side of the insect, barely going through. A large pin is then inserted through the cork square. In figure 98,*d* is shown another method of using the micro-pin, with a strip of ordinary white paper, the pin inserted through opposite sides. Some use for certain insects bits of horse hair instead of micro-pins. One end of the hair is pushed into the side of the insect, and the other is inserted in a drop of shellac placed at the proper height on the pin. Another way of making double mounts is the use of an elbow pin as in figure 98,*c*. A fine pin has its larger end wound tightly a few times around an ordinary pin, and the tip bent upward enters the under side of the insect. The principal fault with this method is in getting the fine pin wound tightly enough to the other pin so that it will not turn nor slip down. Dealers sell machines for making these elbow pins.

FIG. 99.—POINTS FOR MOUNTING INSECTS.

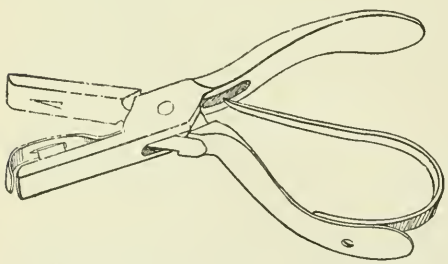

FIG. 100.—AN INSECT PUNCH FOR CUTTING TRIANGLES OR POINTS.

For many small insects, especially beetles, Hymenoptera, and Hemiptera, most entomologists use points—slender, triangular pieces of cardboard, as shown in the illustrations (figs. 98, *a*, 99). The dealers have punches (fig. 100) for making these triangles or points,

but the points are usually much better when cut by the scissors Seven to 8 mm. is a standard length used by the majority of collectors. Different insects require a different width at tip, and this is readily gauged by one in cutting them with the shears. These points should be of very stiff paper, or a thin cardboard of such texture that they will not readily bend, yet not too stiff for a No. 2 pin. A bright pin, No. 2, 35 mm., is pushed through the broad end of the point, and the insect is fastened to the tip of the point by a little gum shellac, or gum tragacanth, or even a good quality of glue. The shellac should be dissolved in pure alcohol, and this requires some time. If there is much water in the alcohol the gum will not dissolve properly. Gum tragacanth is dissolved in water. A drop of corrosive sublimate or spirits of camphor added to the water will prevent the gum from souring. Mr. Dury recommends the following glue: One-quarter ounce gum arabic, one-eighth ounce gum tragacanth, dissolve in hot water, and to this add one-half teaspoonful of glycerine and 4 drops of carbolic acid. Shellac has an advantage over most glues in that it requires but a very small amount to hold an insect.

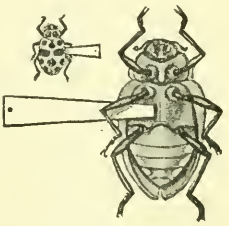

FIG. 101.—METHOD OF GLUING BEETLE ON PAPER POINT.

The insect should be mounted so that when the point is directed to the left the head of the insect is away from the person. The point should hardly be as high up on the pin as is a specimen. In the case of Coleoptera and many Hemiptera and Hymenoptera, the insect is mounted with its back uppermost, but with many Hymenoptera and with some flies the back should be outward. The shape of the insect will be the guide in this matter. For many Coleoptera it is well to depress the tip of the point slightly so that it will fit to the insect. The idea should be to obscure as little of the insect as possible. In figure 101 one sees how the point should attach to the insect and yet leave the insect readily observable from beneath. The beginner is apt to use too much glue or shellac, but by practice one can get expert in this matter and increase the neatness as well as the value of the collection.

When mounting up a large number of specimens, put shellac on a few points only at a time. It is handiest, at least with beetles, to lay the insects upon their backs, and then with the point dipped in shellac pick up the specimen; then, when upright, press on the specimen slightly to fasten it securely to the point. With insects having long legs one may pick them up by a fine forceps and place them on the point; then, by use of a lens, arrange them properly on the tip.

Some use a fine brush, moistened, for picking up the insect and transferring it to the point. However, with some insects one is apt to use too much moisture. In pinning small specimens with micropins it is useful to lay the specimen on a piece of velvet or a folded handkerchief. One can thus do the work under a lens. Some have advocated the mounting of duplicates on strips of cardboard, as in figure 102, and then pinning up these strips several on one pin. It is, however, hardly to be advised, as one is too apt to leave such specimens without further attention—an eyesore in a good collection.

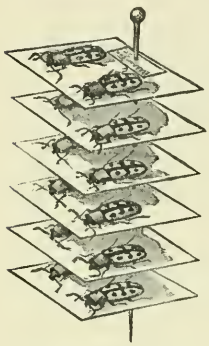

FIG. 102.—A METHOD OF MOUNTING DUPLICATES.

For especially long or slender insects a double-tipped point (fig. 98,*f*) is handy, the thorax of the insect resting on one tip and the abdomen resting on the other tip. It is well to cut the points in winter time and have them on hand for use when the collecting season opens in the spring. Leaves showing the work of insects should first be dried, and then a small square of cardboard pinned above and below them to hold the leaf in place.

The appendages of insects may be mounted on the following plan, proposed by Doctor Horn: A hole, round or square, is cut in a piece of bristol board. A cover glass is fastened to one side by a thin circle of shellac. Into this cell put the appendage and cover it with a drop of Canada balsam; then put on another cover glass. This preparation may be pinned, and placed in the collection by the side of the insect.

SPREADING INSECTS.

Such insects as butterflies and moths, dragonflies, etc., should have their wings spread out at right angles to the body (fig. 103). This is effected by the use of spreading boards (fig. 104), such as shown in the figure. Two strips of some soft wood, as linden, pine, or white wood, are fastened at the ends to braces, leaving a narrow groove between them. A strip of cork or pith is tacked or glued to the under side of the boards covering the groove. Many entomologists prefer to have the boards inclined slightly upward; others have them level. Some cover the boards with a thin strip of cork. Sometimes a board is fastened to the bottom of the braces and the cork attached to this; this gives more room for the legs of the insect.

FIG. 103.—A MOTH, WITH WINGS SPREAD.

One should have several boards with different width of space, so as to admit insects of different sizes. The space should be just a little wider than the body of the insect. The wings should be carefully pulled forward and held down by a pin or spreading needle (fig. 106), and then covered with paper strips with a stout pin at each end (fig. 105). The specimens should be as uniform as possible, and the rule is that the hind borders of the front wings should form a straight line. This, however, is sometimes a trifle too much. Care

FIG. 104.—A SPREADING BOARD.

should be taken that in pulling the wing forward one does not injure it. The pin or needle should be inserted just behind a strong vein near the base of the wing. Some utilize a spreading pin, which is made by twisting with the pliers a beheaded insect pin tightly around and near the point of a large mourning pin and forming a right angle to it. One can insert the mourning pin in the board behind the wings and the insect pin will hold the wings flat. The antennæ should be extended at or near the front margin of the wing, and the abdomen raised and supported, if necessary, by two pins placed crosswise beneath it.

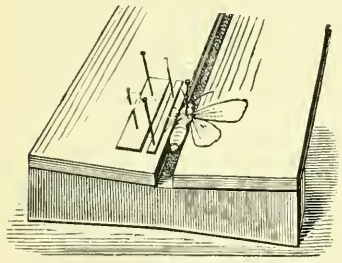

FIG. 105.—A SPREADING BOARD FOR LEPIDOPTERA.

After one board is filled it should be put away in a box or case where it will be safe from dust until the specimens are thoroughly dry, when they may be removed and placed in the cabinet. A little naphthalene should be sprinkled in the drying box to prevent the incursion of Anthrenus. Some make an elaborate drying cage (fig. 108), with sides of fine wire screening and shelves or racks to hold the boards. If the insects are removed before they are thoroughly dry the wings will later spring back and droop down. Some entomologists bake the spread specimens, putting them in a slow oven for an hour or so, watching them carefully so they will not scorch. This enables one to dry them much more rapidly and thus handle a larger amount of material in a short time. Opinions differ as to the value of baked as contrasted with naturally dried specimens, and it is likely that climatic conditions have some effect.

Some use pieces of heavy glass instead of paper strips to hold the wings in place, but these are apt to slip and rub the wings. Frequently it is possible to fill the board with spread specimens, and then put two long strips of paper over the entire lot, pinning them down between the insects. Some entomologists have advocated the spreading of certain insects in an inverted position. Those which have the origin of the wings as high as the top of the thorax, as dragonflies, sawflies, etc., may be advantageously spread in this fashion. A long strip of cork or soft wood is fastened upon two or more low braces. Small holes are made here and there along the middle. The head of the pin is pushed through the hole till the back of the insect rests upon the cork or wood. The wings are then spread and fastened from beneath. By this method the legs are less liable to become broken than by the usual fashion.

FIG. 106.—A NEEDLE FOR SPREADING INSECTS.

All Lepidoptera should be spread, although with a series of one species it is well to have one or two specimens with the wings in the natural resting position. Nearly all the Neuroptera, the stoneflies, the dragonflies, the caddiceflies, the Cicadas, many Fulgorids, most of the Orthoptera, and sawflies, should be spread before they are suitable for study or the cabinet. Most other insects are not spread, and for purposes of study are better so, since the spread wings are often in the way when one examines them by a hand lens. For a museum collection many of the flies and Hymenoptera look better if spread. With beetles and Heteroptera it would be well if one or two specimens of each species could be spread, since it is impossible to see the venation of the hind wings of these forms when mounted in the usual way, and specialists in these groups know little about these important structures. With many beetles it is not easy to spread the elytra out horizontally, but if they are raised and slightly divergent the under wings may be brought out and spread so that all parts may be examined with a lens. Frequently with Orthoptera and some other insects the wings of one side only are spread. This saves space in the cabinet and also shows how the insect holds its wings when at rest. It does not, however, look so well with Lepidoptera.

FIG. 107.—SPREADING PINS: *a*, FOR LARGE INSECTS; *b*, FOR MICROLEPIDOPTERA.

For Microlepidoptera, small moths, flies, and other tiny insects a modification of the spreading board has been devised, as shown in the illustration. It consists of a small block broader at base, with a groove along the top filled with pith, and deep enough for a micro-pin. Strips are fastened over each side, leaving a narrow groove between them. These blocks may be made solid and the groove may be cut triangularly, so that the bottom is a little wider than the top. Mr. Busck has devised a method of carrying these Micro spreading blocks in an insect box, as shown in figure 109, the box holding several rows of the blocks, and triangular strips of wood fitting down between the blocks to hold them in place. One may carry this box out on a long collecting trip and spread the captures as desired.

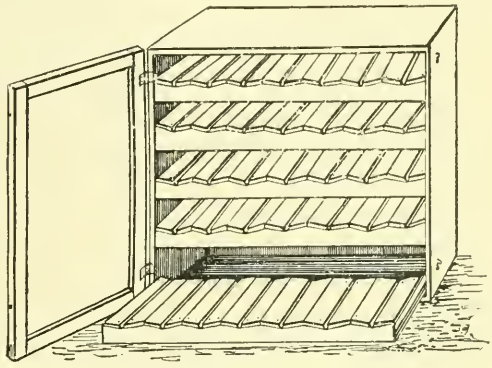

FIG. 108.—A DRYING CAGE.

Micros should be spread when fresh, if possible. If it is necessary

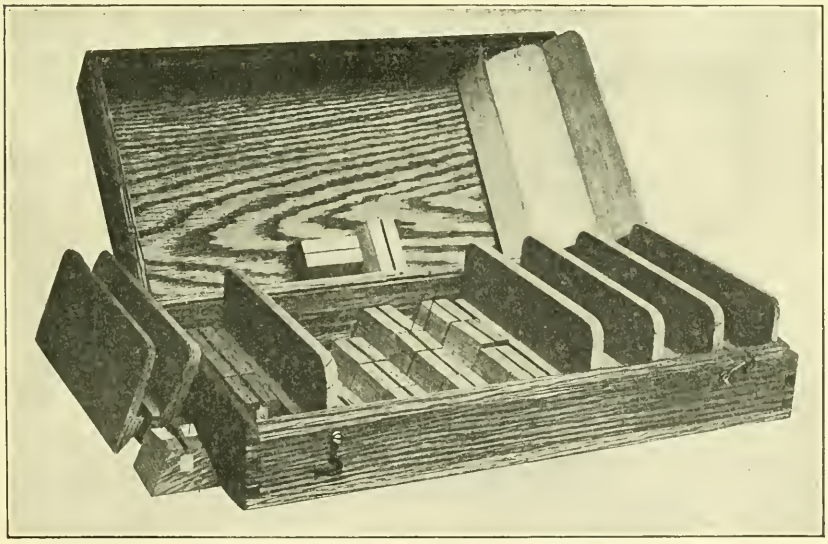

FIG. 109.—THE BUSCK BOX, FOR CARRYING SPREADING BLOCKS FOR MICROLEPIDOPTERA.

to wait, then after the specimen has been pinned a slight puff blown against it from behind will diverge the wings and make more easy and successful the job of relaxing and future spreading. In the field it is often well to pin Micros in a tin box with a piece of moist cork.

This keeps the specimen from drying out, as it is apt to do shortly after death.

In spreading the Microlepidoptera one must exercise great care and at first much patience. The upper side of the wing should not be touched with a pin. The wings may be brought forward into place by the instrument shown in figure 107. This is made by inserting a stiff bristle into a piece of cork and a pin nearly at right angles to it. Holding it by the head of the pin the point of the bristle may be passed under the wing, lifting it up and sliding it forward into place. A piece of paper is then pinned down over the wings, the forward pin being put in first. In putting down the strips of paper one must be careful to lay them right side up, for in cutting strips of paper one edge is always slightly turned, and if this edge is turned down on the wing it may scratch and rub the scales. The paper should entirely cover the wings, else the tips may turn up in drying.

Insects that are in papers or dry in the cabinet may be spread by softening or relaxing them. This is accomplished by placing them in a relaxing jar for a day or two. The relaxing jar is made of any tight metal box or earthenware jar, with an inch or so of moist sand in the bottom and a few drops of carbolic acid to prevent mold. One must not have the sand too moist, else the specimen will become wet. Some insects relax much more readily than others, so that it is well to have two or more jars. If there is much moisture in the sand it is better to put a piece of blotting paper over the top of the box or earthenware crock before replacing the lid. This prevents the drops of moisture which may accumulate on the lid from falling on the specimen. For relaxing a few small things one can put them in a saucer with some moist blotting paper, and cover them by an inverted saucer.

LABELING SPECIMENS.

After an insect has been pinned, or spread if necessary, the next step is to properly label it. The older entomologists had very general notions about this matter, and one is fortunate to find their specimens labeled with the State in which it was captured. But now it is considered necessary to have at least both the name of the town at or near which the species was taken, and the date of capture, upon a label pinned beneath the specimen. These locality labels (fig. 110) should be printed in small type, diamond preferred, on a good quality of paper, as linen ledger, and as shown in the illustration. Some entomologists prefer to have the state abbreviation at the right end of the label. Personally, however, I prefer to put it at the left hand. There should be no spacing between each label of one row, so that but one cut with the scissors will be necessary to separate them. The date can be written in the blank space as follows: 9 June 09, or

9–VI–09. It is not advisable to write 9–6–09, for one will get confused as to whether it is the 9th of June or the 6th of September. It is not advisable to have a label of more than two lines. Some entomologists, however, prefer to have the collector's name as the third line of the locality label.

The label should be pinned through the middle and a short distance below the specimen, so that it does not interfere with the legs. The label with most insects should extend lengthwise with the insect, but with those having the wings spread it is customary to have the label extend with the wings. For double mounts or for specimens glued on points, the label is commonly pinned through one end, so that its main length is on the same side of the pin as the point or piece of cork.

Below the locality label there are often other labels bearing the name of the collection or collector, a sex label, and labels indicating the circumstance of collecting. The latter, known as ecological labels, are increasingly popular, and should be used wherever possible. Insects, such as bees, etc., taken from flowers, should bear a label with the name of the flower; if taken at light, a label indicating that fact, etc. All phytophagous species should bear the name of the plant upon which captured. Some of these labels, which will be useful in particular cases, are as follows: At sugar, at light, electric light, twilight, sweeping herbage, from foliage, under bark, in moss, in meadow, in swamp, by stream, over pond, tree trunk, in fungi, sifting leaves, dead log, under stone, on ground, etc. Anyone can readily think of many other ecological labels which will be of value in his particular group. Many prefer to have these labels printed in two lines, as are those of locality and date. This may be accomplished by combining this label with that of the collector. The value and interest of a collection is vastly augmented by these ecological labels, and they are a good guide for finding other specimens of the same species. For sex labels the sign ♂ (Mars) is used for the male, and ♀ (Venus) for the female, and ☿ for the workers or neuters.

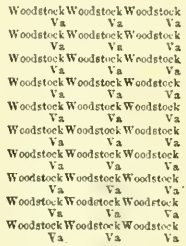

FIG. 110.—LOCALITY LABELS.

By practice one can learn to write a fair hand in minute letters, so that written labels may take the place of the printed ones. In writing labels one should have especially fine pens, drawing pens, or crow quills, and use only india or waterproof ink. Good printed labels, however, can be bought for about 25 cents a thousand. Never put upon a pin a label so large that it requires to be folded, and always

write labels in as small a hand as can be read without a lens. It looks badly in a collection to see unnecessarily large labels.

A method was devised by Mr. Hinds for photographing typewritten labels. He describes it as follows: "When a series of labels for a new locality, food plant, or collector is desired, the typewriter is used to write out in columns each desired label a proportionate number of times. A black ribbon is used, with clear white paper. If possible each column should be composed throughout its length of the same number of spaces, and a single space is sufficient to separate the columns. Attention to these points facilitates the cutting up of the labels. Prints are made upon a special portrait paper, and if the work of negative making and printing has been well done a very good, durable label may thus be obtained."

It is sometimes necessary with long words to abbreviate the name of the town. One should be very careful not to abbreviate more than absolutely necessary, and then in such a way that there can be no mistake about the name. For example, for New Rochelle, "New Roch." is better than "N. Rchll." It is better to have a long label than one which may be misunderstood. Some collectors like to have small printed labels with the specific name of the insect, sometimes abbreviated, pinned to each specimen near the end of the pin; it facilitates rearrangement and exchanging.

For keeping notes and records of specimens in a book, a number should be attached to the specimen corresponding to the number in the note book, but the locality label should never be omitted from these specimens. In some groups of insects it is necessary to use other labels. Insects reared from galls, for example, should have a number connecting them with the gall, and if any part of the insect has been removed to be mounted upon a slide for microscopic examination this fact should be noted on a label attached to the specimen.

Specimens placed in vials of alcohol should have the label, if not printed, written with waterproof ink on extra good quality of paper. The label should be allowed to dry thoroughly, and then placed into pure alcohol, or as pure as one can obtain, for half an hour or so; then it should be put within the vial, never pasted on the outside. If the label is long, it may be folded or formed to circle around the vial. These labels for alcoholic material need not be written as small as those for pinned specimens, but should be smaller than ordinary script. For labeling specimens on slides a square label of gummed paper should be used. These can be obtained in books from the dealers in microscope supplies.

In all matters of labeling one should give the information in as plain language and as brief a form as possible, and avoid all signs that can only be interpreted by reference to note books. Much

information often put in a note book could be placed on a small label, and is thereby more certain to be always connected with the specimen. Bits of colored paper should never be used for labels. Where one has a considerable variety of labels it is handy to place each kind in an envelope and arrange the envelopes alphabetically in a small tray. Pencil labels that have been for years in alcohol sometimes become illegible. Mr. Henshaw has discovered that the writing can be brought out by gently washing the labels in yellow ammonium sulphide. This, however, will not permanently restore them.

In the matter of keeping notes collectors follow their personal idiosyncrasies to the limit, but some sort of a card system is considered best by practically all who have had much experience. In the making of notes follow Professor Comstock's advice, "Be sure you are right, and then look again."

STORAGE OF SPECIMENS.

A familiar method of collecting Lepidoptera and dragonflies is to put them in folded papers and store them in boxes until one has more leisure to mount and spread them. These papers are prepared as shown in the figure, the piece of paper being about one-half or one-third longer than wide. It is folded in the order of the numbering in the figure. After folding the papers they should be ironed so that the creases will stay put. These papers should be made of various sizes to accommodate the different sizes of insects. A number should be prepared in the winter time. This method of preparing insects is known as "papering" the specimens (fig. 111). The paper should not be too stiff nor glazed. Newspaper usually makes very good material, although some of these now are hardly good enough for this purpose.

After the specimens have been put in the paper with the wings folded over the back, one can write on the outside of the paper, beyond the edges of the insect, the locality and date. They should be stored in boxes. If the insects are perfectly dry, they may be kept in tin boxes, but tight wooden boxes are perhaps better, and in either case some flake naphthalene should be sprinkled over them. Insects thus prepared can be sent through the mails with safety. Some arrange these papered specimens in long card trays, with a card here and there to indicate the contents or localities.

Many of the minute Hymenoptera, Diptera, and Hemiptera may be stored in pill boxes nearly filled with torn bits of tissue paper. Beetles and Hemiptera may be packed in a small flat box between layers of velvet. Cotton should not be used, but when covered with soft paper will do for all except fragile insects. These methods

of storing material are useful on extended collecting trips. Some collectors put up the larger insects, as Orthoptera, beetles, bees, etc., in tubes of paper. The insect while yet fresh is laid on a piece of soft paper, which is then rolled fairly tight around it and the ends tucked in. Others make tubes of various sizes by wrapping a piece of soft paper around a lead pencil or other cylindrical object, and turning in one end. Then put the insects in the tube and plug up the other end with cotton. All tubes and boxes of dried specimens should be packed in larger boxes with plenty of flake naphthalene.

In relaxing such specimens for pinning one should put the papers or tubes into a relaxing jar, and not attempt to remove the insect

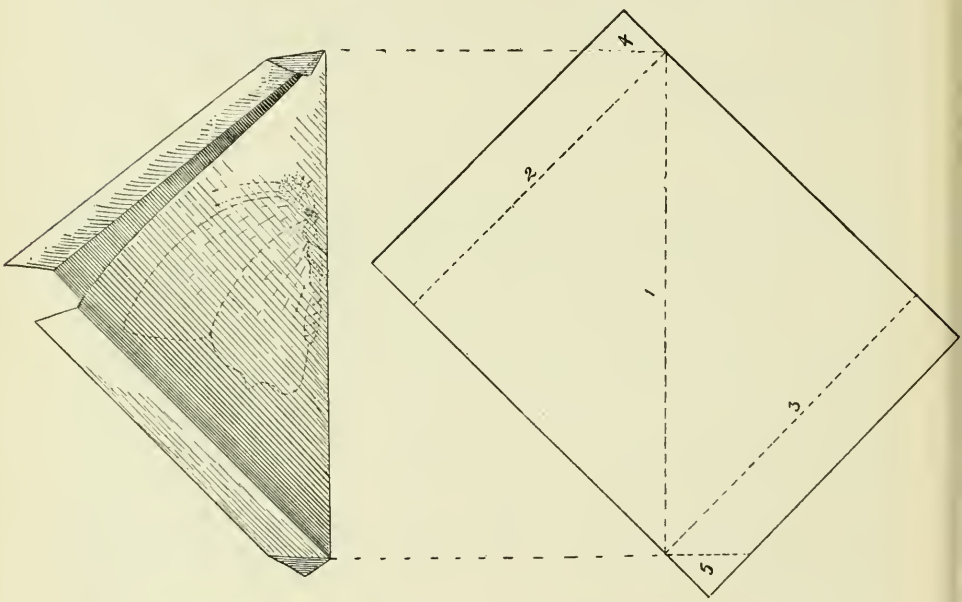

FIG. 111.—THE PAPER ENVELOPE FOR LEPIDOPTERA, AND METHOD OF FOLDING IT: 1, FIRST FOLD; 2, SECOND FOLD, ETC.

while dry from its cover. Collectors sometimes put up Coleoptera and Hemiptera in glass vials with clean sawdust, dampened with 9 parts alcohol and 1 part carbolic acid. A layer of sawdust is placed in the bottom, then a layer of insects, then a layer of sawdust, etc. It keeps them slightly moist so they can be easily pinned, but they require cleaning with a fine brush before they are suitable for the cabinet. Lepidoptera and Neuroptera should be put in papers; beetles, Hemiptera, and Orthoptera may be packed in boxes, tubes, or sawdust, or even in alcohol; Hymenoptera, and especially Diptera, should be pinned on all trips; in fact it is better to mount at least one or two specimens of the Coleoptera, Hemiptera, and Orthoptera.

MOUNTING SPECIMENS ON SLIDES.

Many insects are so minute that they can not be pinned, and can only be studied by the aid of a microscope. These insects are preserved by mounting them in Canada balsam upon a piece of glass called a slide (fig. 112). These slides, 3 inches long and 1 inch wide, the Canada balsam in small tubes, and the cover glasses to place over the insects can be purchased from all dealers in microscope supplies. A drop of the Canada balsam is put on the center of the slide and the insect put in, its legs or wings arranged with pins, and then the cover glass put on and pressed slightly so that the balsam will spread out and fill all the space. Care should be taken not to use too much balsam, for the amount should be no thicker than the thickness of the mounted insect, else one can not use the higher powers of the microscope. Sometimes it is useful to heat the balsam after the cover glass has been put on. This is done by means of a small alcohol lamp, purchasable from the dealers. This heating induces the balsam to harden more quickly, but with many soft insects too much heating will break the skin or drive out the juices and discolor the mount.

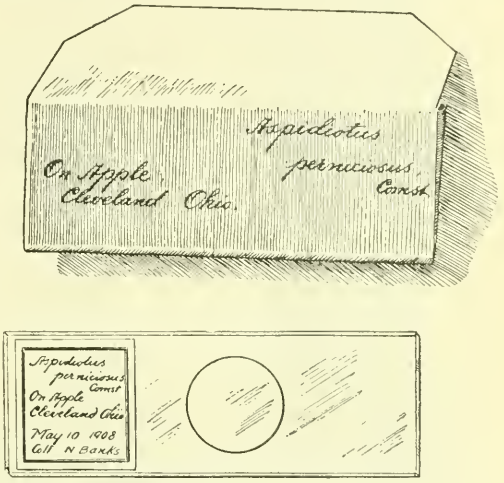

FIG. 112.—A BALSAM SLIDE MOUNT AND JACKET COVER FOR SAME.

There are other media than Canada balsam in which to mount specimens, and if any of these are used it is necessary to cover the edge of the cover glass with some material such as Brunswick black to prevent evaporation. It is not necessary to seal up balsam mounts. Insects for mounting are prepared in different ways. Sometimes it is better to kill them in hot water or in acetic acid. If the specimen has been in alcohol this should be removed by a bit of blotting paper, and the specimens placed in clove oil or xylol for a few minutes, heated slightly, and then mounted in the balsam. Different methods will be found to apply to different insects or their parts. After the mount has been prepared the slide should be labeled by attaching a square gummed label to one end of the slide. The slides should then be left flat until the balsam is dry, and afterwards may be arranged in a box or tray (fig. 113). Wooden boxes are commonly used, each having space for

25 slides. Others lay the slides on sliding shelves of a large box or case.

Mr. Marlatt has perfected a way of keeping slides on the card system which is superior to all other methods. Each slide is put in a small manila envelope or jacket (fig. 112), expressly made for this purpose, and these placed on edge as cards in a tray. The cabinet, holding several trays each, with three rows, is made by dealers in library supplies. On the outside of the envelope may be written the name and locality of the specimen or other information. Guide

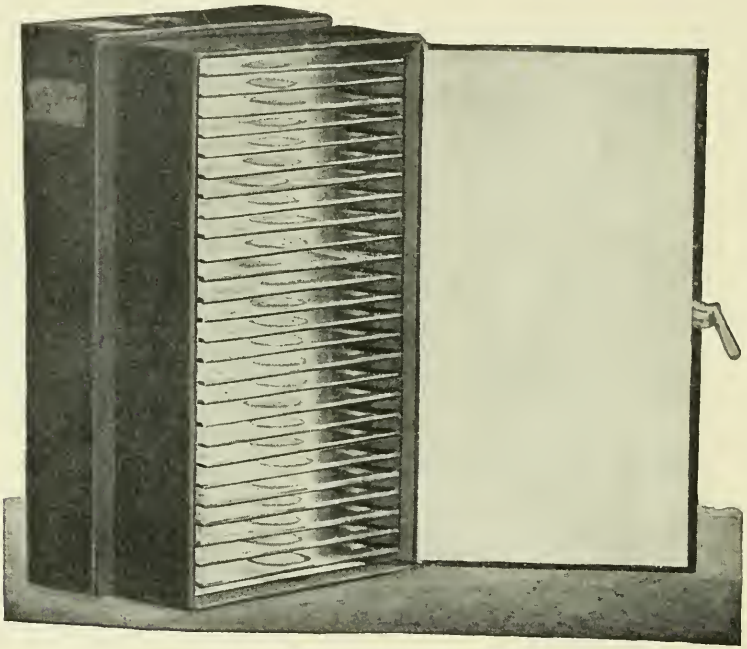

FIG. 113.—A CASE FOR STORING SPECIMENS MOUNTED ON MICROSCOPE SLIDES.

cards, with the name of the species or the genus, may be used to separate the series. By this method one may insert new slides or new species at any time in their proper places, and all are secure from dust. One must be careful that the balsam is fully dried before putting the slides in these jackets.

Most of the wingless insects are best studied when mounted on these slides, as also larval and immature stages of other insects, and the sections of mouth-parts, etc. For studying the general structure more elaborate methods are required, which may be learned from a number of books on microscopical and histological technique.

PREPARATION OF LARVÆ.

A method of preserving caterpillars by inflation has long been used by lepidopterists. The larvæ should be killed in a cyanide bottle or in alcohol. Cyanide is generally considered the best for most larvæ. The caterpillar is placed on a piece of blotting paper, a pencil is rolled over the larva from the head to the tip of the body, thus protruding the tip of the alimentary canal. This is snipped off by a pair of scissors or a sharp knife, and then by rolling a pencil, as before, a number of times over the larva the contents are squeezed out of its body. One should be careful to do it rather slowly, at least with delicate larvæ, so that the skin is not broken, for if rubbed too hard or too long the pigment may be removed from the skin. The caterpillar should be moved about on the blotting paper during the operation, so that it is not soiled by its own juices.

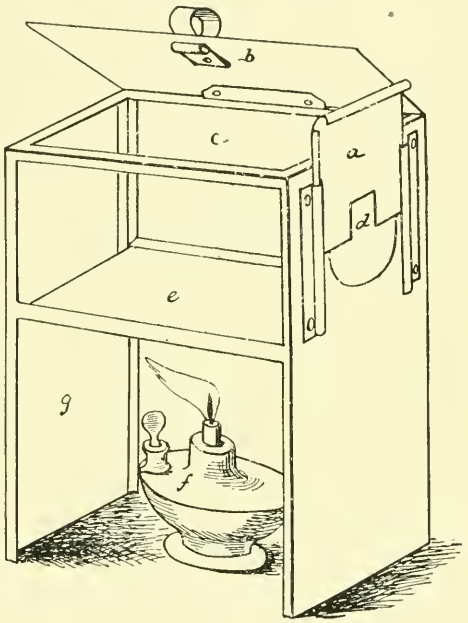

FIG. 114.—A DRYING OVEN FOR THE INFLATION OF LARVÆ.

A glass tube with its tip drawn out to a fine point is then inserted into the anal opening. The skin may be fastened on the slender point by a bit of thread or a drop of glue. If the glass tip fits rather tightly into the aperture, then the skin may be placed a moment in the oven and then withdrawn. This will stick the skin to the end of the glass. A spring or clasp of steel may be so arranged as to hold the larva to the tube, or the skin may be held to the glass tube by a common insect pin bent around the tube and then forward, with the tip recurved (fig. 115). One may inflate the skin by blowing in the tube; but a more effective way is to have a rubber tube on which is a large rubber pneumatic bag and a smaller inflating bag at the end. By squeezing the inflating bag the larger bag becomes inflated, and this makes a steady pressure upon the larval skin. This operation of inflating the larva should be performed over a small tin oven, as shown in figure 114. The glass tube with attached larva is inserted through the hole "*d*." If one expects to inflate many larvæ, an apparatus of this sort will be very useful. But if only a few, or, for

a beginner, a bottomless tin can, supported by a wire frame over a flame, is an effective substitute. Mr. Merrick has devised a very elaborate apparatus for inflating larvæ which is warranted not to injure the specimens and demands but little attention. It is figured in Entomological News, 1908, page 10.

The inflated specimen is pinned as follows: A piece of copper wire is twisted around the middle of a small cube of cork, which is pierced by a pin. Then the wire is bent to form an oval or diamond-shaped loop about one-sixth of an inch long and again twisted to the end. This twisted part is inserted into the larval skin or the larval skin mounted upon it from below by a little shellac. With practice one can become expert in inflating larvæ, so as to preserve the shape and natural colors. Instead of a fine-pointed glass tube some use a straw, but this is hardly as satisfactory a method. The blown larva may also be preserved by placing it in a glass tube and fastening this tube in the collection.

A great variety of larvæ may be inflated by this method, but the larvæ of Coleoptera, Diptera, and Hymenoptera keep very well in alcohol or some similar liquid. Some entomologists have recommended preparing the larvæ of Microlepidoptera without pressing out their contents. This is done by placing them in a tin box of sand and heating it with the flame from an alcohol lamp. The gas generated in the larva inflates it and keeps the skin stiff when dry. They may be gummed to cardboard points or mounted in the same way as other lepidopterous larvæ. Mr. Busck, however, prepares the larvæ of Microlepidoptera on the same plan as used for the Macros. The glass tubes have very fine points. The contents of the larva is rolled out as usual. The point of a glass tube is then inserted into the end of the larva and then for a moment put in the oven. This heating attaches the skin to the glass tubing. Then it is blown as usual by the rubber bulb. When dry, he does not attempt to remove the larva from the glass, but cuts the glass near the larva and mounts it by the use of a micro-pin touched with shellac and fastened through the tube into the larva, the other end in a small cork square mounted upon an ordinary insect pin. This work should be done as rapidly as possible, for the skin will dry if not blown at once after the removal of the contents.

FIG. 115.—A CLIP FOR HOLDING CATERPILLARS.

PREPARING WINGS FOR STUDY.

It is very necessary in studying the venation of Lepidoptera to denude the wings or to bleach the scales. Removing the scales with a camel's-hair brush is the quickest method, but one is apt to injure the membrane. Most entomologists use some sort of bleaching process. Several of these are described below.

Doctor Dimmock used chlorine in the form of chloride of lime. The wings are first soaked in pure alcohol. The chloride of lime is dissolved in 10 parts of water and filtered. A little is poured into a shallow vessel. The wings are then transferred to this, and in an hour or two are thoroughly bleached. When sufficiently clear the wings are dipped into dilute hydrochloric acid, and then washed in pure water and mounted upon a slide in Canada balsam. Doctor Howard recommended the following process: The wing is removed and mounted upon a slide in plenty of Canada balsam. The slide is then heated over the flame of an alcohol lamp until the balsam spreads well over the wing. Just as it is about to enter the veins the slide is placed on ice, or, in winter time, outside of the window, for a few minutes. This hardens the balsam immediately and prevents it from entering the veins, which remain filled with air. With practice one can select just the proper time when to remove the slide from the flame and secure the best results. Doctor Smith recommends the following method: He puts the wings in a mixture of chlorine and hydrochloric acid. This decolorizes the wings at once, and they may be mounted within a few minutes. The advantage is in the rapid work. The disadvantage is in the vile odor of the chlorine gas which is liberated by the mixing of the two liquids. Doctor Calvert places the wings in a caustic potash solution for twenty-four hours; then washes in water fifteen minutes; then in a watery solution of Bordeaux red for twenty-four hours; then washes in water and floats on cards to dry.

Mr. Tower recommends bleaching wings as follows: Place the wing in a crucible partly filled with hydrogen peroxide and cover it. Boil until the scales are bleached. Wash in water for fifteen minutes; then in 70 per cent alcohol for a like time. Stain from one to three hours with cyanin, gentian violet, or rosaniline. Remove from stain and wash for fifteen minutes in 50 per cent alcohol, and for thirty minutes in water. It may be necessary to repeat this washing if the stain is not removed from the membrane. Then mount in glycerine jelly. For balsam mounts, bleach as above; then wash in water, and in 50 per cent alcohol each for fifteen minutes; then remove and stain in cyanin for two hours; then wash in 50 per cent, 70 per cent, and 90 per cent alcohol, ten minutes in each. Remove the surplus stain and air bubbles by thoroughly washing; clear in oil of cloves;

and mount in xylol balsam. Wings treated by this method may be successfully photographed. Mr. Hall, in Entomological News, 1902, describes his methods of bleaching and photographing the wings as follows: "The wings are first moistened with alcohol, and then put in eau de javelle solution until thoroughly bleached. They are then removed to fresh water for five or ten minutes to remove the lime solution, thus preventing deposits in drying. Remove the wings by immersing a piece of paper in the water and floating the wing upon it, much in the manner of mounting seaweeds. The paper and wings are then removed together, and the surplus moisture removed with blotting paper. Lay a clean piece of paper over the wing, and place between the leaves of a book and dry under pressure. When dry the wings separate easily from the paper, and may be fastened to a sheet of glass with an atom of shellac. Place the sheet of glass in an ordinary photographic printing frame with a sheet of sensitive paper, and place in the sun until the paper turns dark and bronzy. On removing the paper the outline and veins of the wings are seen in exquisite detail in white against a dark ground." The wings of other insects can be used without preparation. Velox or any of the developing papers may be used, and then the work can be done in the evening.

Mr. Busck, for the Microlepidoptera, uses a very neat and successful method. The wing is carefully broken from the body, and then placed in a shallow dish of alcohol. Then it is floated out on a glass slide, and by the use of a fine badger-hair brush under a lens he removes the scales, occasionally dipping it in the alcohol to wash off the loosened scales. When clean it is floated on the center of the slide, and when about dry is covered with a three-fourths inch cover-glass. A slide label 1 inch square, with a circular hole one-half inch in diameter, is pasted down over the cover-glass, thus securing it to the slide. This one-half inch hole could be cut by a punch, but Mr. Busck moistens a one-half inch cover-glass, sticks it to the gummed side of the label, and then after pressing it down cuts it from above by a pin point or the tip of a sharp knife blade.

PRESERVATION OF MATERIAL IN LIQUIDS.

Alcohol.—Alcohol is the most useful and convenient liquid for preserving the immature stages of many insects, and for spiders, mites, centipedes, etc. Moreover, it is of increasing use in the preservation of much other material. Many of the Neuropteroid insects, such as mayflies, Perlidæ, Psocidæ, are well kept in vials of alcohol. And many Orthoptera, as cockroaches and earwigs, and some Neuroptera, as dragonflies and scorpion flies; some Diptera, as crane-flies, and a great many Hemiptera and Coleoptera are as

well preserved in alcohol as when dry, and, whenever one has an abundance of specimens, it is well to put up some in tubes or vials of alcohol. Specimens so preserved are better suited for dissection or morphological studies than dry insects.

The best kind of vial in which to keep alcoholic material is a flat bottom necked vial like the ordinary homeopathic or "homo" vials sold by all druggists. The kind kept in stock by drug stores is frequently of poor quality, but they can order a better quality of heavier glass if asked, or these can be purchased from dealers in entomological and microscope supplies. It is best to have vials of but two or three sizes, 1, 2, and 4 dram, and for a collection of one group of insects one size will usually be sufficient. Many prefer to use straight tubes instead of necked vials. These can be obtained from the dealers. Professor Comstock has devised a square bent necked bottle which enables one to put the specimen in the box with the pinned insects; but it is better to keep alcoholic material in a separate collection. Professor Riley also devised a method for keeping vials in the collections, the bottle resting upon a block. This method has been shown to be far inferior to keeping specimens in the ordinary upright bottles. Others put a pin through the stopper of the vial and pin the bottle at a slight angle in the collection. But, as before stated, it is far better to keep alcoholic material by itself than mixed with the pinned specimens.

Cork stoppers, if of good quality, are superior to any other kind, but the difficulty is in obtaining good cork. The extra expense of the best quality of cork will be repaid by the better results. As one goes over his collection from time to time those stoppers that are poor can be replaced by new ones. The trouble in getting good cork stoppers has led many to the use of rubber. The great majority of rubber stoppers that are placed on the market are of poor quality and form crystals of sulphur which fall upon the specimens. This tendency may be reduced, it is claimed, by soaking the stoppers for an hour or so in hot water. To insert a rubber stopper in a vial one should put beside it a slender insect pin. This enables the compressed air to escape; when the stopper is fully in, the pin is withdrawn.

The percentage of alcohol to be used varies with the group of insects. If the insects have a hard body, 90 to 95 per cent will not injure them, but for most soft-bodied forms, as larvæ and spiders, 70 to 80 per cent is better. A good plan is to put the specimens first in a weak solution, 60 to 70 per cent, and then later in a stronger liquid. For many larvæ it is well to dip them into boiling water, or just bring them to a boil in water, before placing them in alcohol. One of the disadvantages of alcohol is its rapid evaporation. If the

cork is poor or the vial cracks, the specimens are soon dried and may be ruined. To obviate this one can mix with the alcohol a little glycerine, about 1 or 2 per cent, or even less. Then if the alcohol evaporates the glycerine will keep the specimens moist for a long while. Specimens that have been dried can often be softened by soaking in warm water, and dipping in hot water, before putting them back in alcohol.

Other liquids.—Various other liquids have been tried as substitutes for alcohol. Formalin is the best as far as results are concerned. In fact, many larvæ preserved in a mixture of 1 part commercial formalin and 10 parts water (a 4 per cent solution), or even in a weaker solution, will keep as well or even better than in alcohol. The vapor from a dish of formalin will injure one's eyes, and when on the fingers it hardens the skin, so that it is not popular with those who wish to study their preserved material. For museum purposes, where specimens are rarely examined, it may find a place. It should be noted, however, that it will corrode zinc, and some styles of jars have zinc tops. Glycerin tends to darken specimens, so should not be used except in small quantities mixed with other

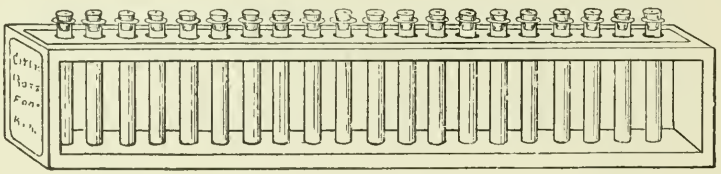

FIG. 116.—THE MARX TRAY FOR SPECIMENS IN ALCOHOL.

liquids. Mr. Barber has tried various combinations of alcohol, formalin, glycerin, and carbolic acid, but found none that would preserve better than formalin. The mixture of alcohol and formalin usually produces a black precipitate, while the addition of glycerin darkened the specimens. A liquid known as synthol has been put on the market, but has no advantages over alcohol, except perhaps in price.

Storing alcoholics.—There are many ways of storing vials of alcoholic material. A cheap way is to take an empty cigar box and divide it into small squares by cross strips of stiff paper or cardboard, on the style of egg boxes. An ordinary box will hold about 60 or 66 2-dram vials. A much better way is the use of slender trays, often called Marx trays, as shown in the illustration (fig. 116). This has a cork top with holes punched in it for the vials. A more economical plan is to discard the cork top and make the tray wide enough for two rows of vials (fig. 117). Then put a cardboard strip down the middle, with side partitions for each vial. Where one does not expect to examine specimens very often, the vials may be canned

in a larger glass jar. For the beginner the ordinary pint Mason fruit jar will do, putting into it two tiers of vials, and then filling up with alcohol. This method is very useful for museums, where many specimens are rarely examined and there is usually insufficient help. A better quality of jar is then recommended, and several kinds are sold by dealers, none of which is as perfect as it should be for

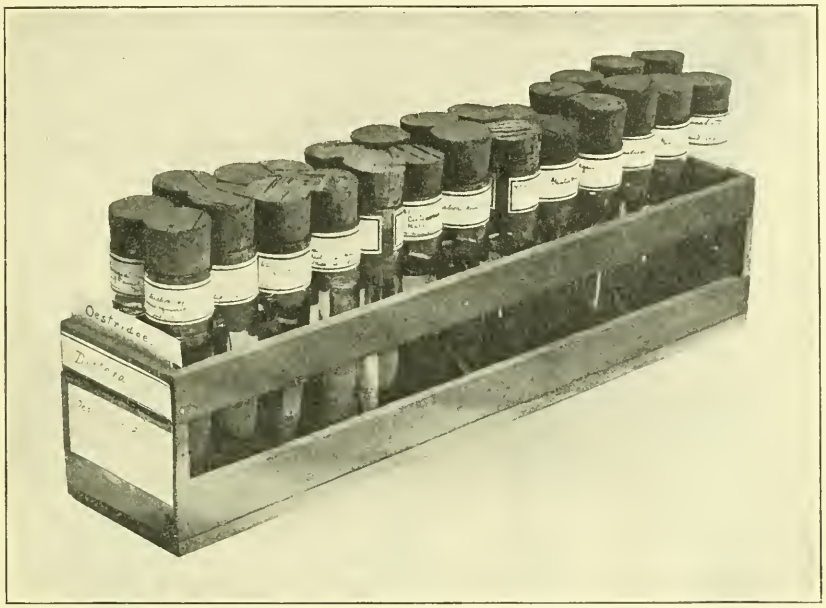

FIG. 117.—THE DOUBLE MARX TRAY FOR SPECIMENS IN ALCOHOL.

storage purposes. For exhibit purposes it is sometimes handy to nearly fill the vial with cotton, which, pressing the specimen slightly against the sides, holds it in place. If the specimen is of a pale color, a piece of dark paper may be put behind it. All collections of alcoholics should be examined twice a year, replacing alcohol and poor stoppers.

SPECIAL DIRECTIONS.

COLEOPTERA.

Beetles are more abundant than insects of any other order. As they have a hard outer skeleton, they are readily handled, and as it is not necessary to spread their wings, they are preserved with less trouble than most other insects. Although most abundant in the Tropics, several large families prefer temperate or even cold climates, and are found as far north as any other insects.

Few persons have had a more extended experience in collecting Coleoptera than Mr. E. A. Schwarz, and the following account has been prepared by him and is given in full:

WINTER COLLECTING.—There are more species of Coleoptera hibernating in the imago state[a] than in any other order, and winter collecting is therefore most profitable in many respects. For instance, great swampy tracts which are inaccessible in the summer season harbor an abundance of rare Coleoptera, which either can not be found in summer time or are found at that season with the greatest difficulty. At the approach of winter, however, all or most of these species will leave the swamp and seek drier ground, where they hibernate under old leaves, under bark of trees, or in rotten stumps near the edge of the swamp. Such places will, therefore, give a rich harvest to the coleopterist late in the fall, during warm spells in midwinter, and in very early spring. If the temperature is below the freezing point, or if the ground is frozen hard, no winter collecting should be attempted, first, on account of sanitary considerations, and also because the Coleoptera then retreat more deeply into the ground and can not be found so easily as when the ground is free from frost. Other good collecting places inwinter are the accumulated old leaves along the edges of forests or under the shrubbery along water courses, thick layers of moss, and the loose bark of dead or dying trees, and, finally, also under the bark of certain living trees, e.g., pines, sycamore, shellbark hickory. Digging in the ground at the base of large trees or rocks also yields good returns. The only instruments necessary for winter collecting are the sieve, the chisel, and the trowel.

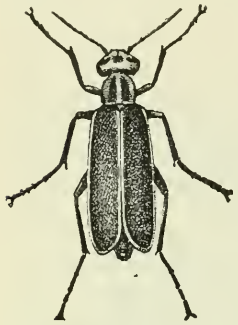

FIG. 118.—A MELOID BEETLE, EPICAUTA MARGINATA.

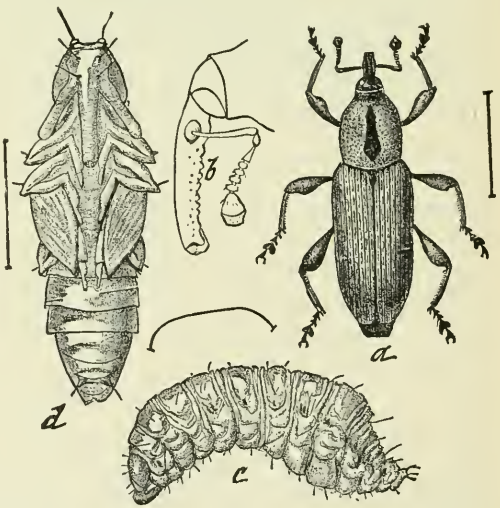

FIG. 119.—A WEEVIL, SPHENOPHORUS OBSCURUS: *a*, BEETLE; *b*, HEAD; *c*, LARVA; *d*, PUPA.

SPRING COLLECTING.—With the first days of spring, collecting becomes a little more varied. The methods used for winter collecting can still be continued with good success. Certain spring flowers, notably

[a] There are a few species of Coleoptera known in Europe which belong to the true "winter insects," i. e., such as appear in the imago state only during winter time, but whether or not we have such species in our own fauna has not yet been ascertained.

willow blossoms, will furnish many valuable species, which are not seen again during the rest of the season.

Myrmecophilous and Termitophilous species.—The early spring is also the best time for collecting the Myrmecophilous and Termitophilous Coleoptera. Termitophilous species have in North America hitherto been found only in connection with the white ants (*Termes flavipes*), and the inquilinous beetles are found running among the white ants in the colonies under stones, loose bark of trees, and more numerously in the interior of old infested trees. Myrmecophilous Coleoptera are by far more numerous in species than the Termitophilous species and are found among many species of ants which have their nests either under stones or loose bark of trees, in stumps or logs, or which construct larger or smaller hills. Upon uncovering a colony of ants under a stone, the underside of the latter as well as the galleries of the ants in the ground should be carefully examined for inquilines, which from their greater or slighter resemblance to the ants are liable to be overlooked by an inexperienced collector. If such colony of ants harbors a rare beetle the subterranean part of the colony itself should be dug out and sifted, but since from the stony nature of the ground this is not always practicable it is to be recommended to carefully replace the stone under which the colony has been found. Upon revisiting the spot again the next day or even a few hours after the first visit additional specimens of the inquilines are usually to be obtained on the stone or in the superficial galleries of the ants. Ant colonies in hollow trees and in rotten logs should be sifted and there is no particular difficulty connected with this operation. Owing to the pugnacious character of the hill-constructing ants it would seem to be a rather unpleasant task to examine a strong and vigorous colony for inquilinous beetles, but the collector must not mind being bitten and stung by the infuriated ants, and after a little experience he will find that it is not such a difficult thing after all to attack even the largest ant-hill. The only thorough way of investigating such ant-hills is to sieve the same, which can be easily done if the hill is composed of sticks and other vegetable débris. If it is built of earth or sand the process of sifting is more difficult and tedious. Another method of securing specimens of these inquilinous beetles is to place flat stones or similar objects on the surface of the ant-hill and to examine them occasionally, when the beetles will be found on the underside of the traps.

FIG. 120.—A LONGICORN BEETLE, SAPERDA CRETATA.

Spring flights of Coleoptera.—On the first really warm days of spring commences the "swarming" season of Coleoptera, when all winged

species are flying about, especially toward evening. On favorable days the number of specimens and species that can thus be found is astonishingly great, and this is one of the few occasions when the coleopterist can advantageously use a light butterfly net. The flying beetles preferably alight and rest on the top of wooden fences (especially newly made ones), on the railings of bridges, etc., where they can be easily seen and secured, or they are attracted in great numbers by the white-painted surface of buildings. This flying season lasts in the latitude of Washington from the end of April to the middle of June, but favorable days are not of frequent occurrence, since a peculiar combination of atmospheric conditions appears to be necessary to induce the Coleoptera to fly about in great numbers.

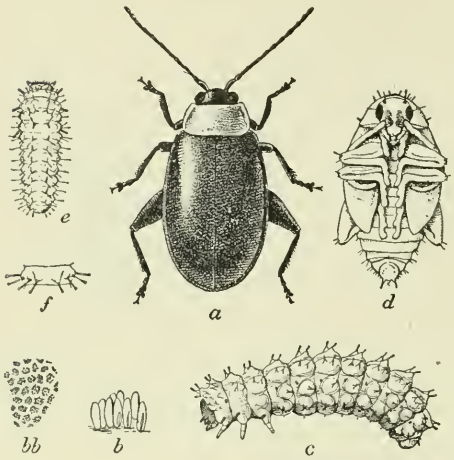

FIG. 121.—A CHRYSOMELID BEETLE, DISONYCHA XANTHOMELÆNA: *a*, BEETLE; *b*, EGGS; *bb*, SCULPTURE OF SAME, HIGHLY MAGNIFIED; *c*, LARVA; *d*, PUPA; *e*, NEWLY HATCHED LARVA; *f*, SEGMENT OF SAME.

Beach collecting.—Along the shores of the ocean and the Great Lakes untold numbers of Coleoptera and other insects fall at this season into the water, and, if the tides, the currents, and the winds be favorable, they are washed ashore by the waves on the sandy beaches, where they often form windrows several inches in height and width. If the collector is happy enough to be at the right place on the right day he has then the opportunity to pick up hundreds of rare species within a very short time and without any trouble. Many of the specimens thus washed ashore are dead and decayed, but the majority are alive and in excellent condition. This "beach collecting" affords also an excellent opportunity for the hymenopterist

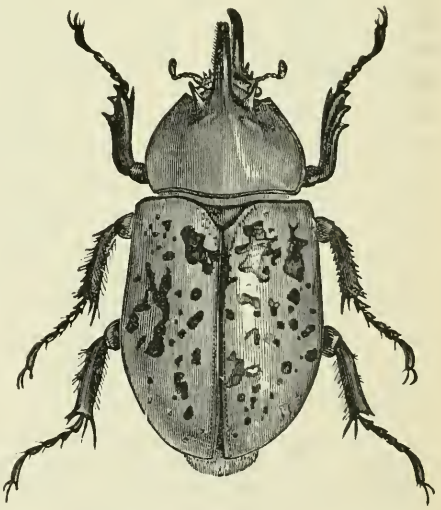

FIG. 122.—THE RHINOCEROS BEETLE, DYNASTES TITYUS.

and hemipterist to secure large numbers of rare species, but favorable days are also here of rare occurrence.

Attracting by lights.—On the beaches, day and night flying insects can thus be captured. Away from the beach night-flying Coleoptera can best be collected at the electric lights of our cities; but, as in the Lepidoptera, not all night-flying species are attracted by the light. Gas and other lights also attract Coleoptera, and the various "light traps" that have been devised and described can advantageously be used for collecting these insects.

Traps.—The method of "sugaring," so important to the lepidopterist, is by far less favorable for collecting Coleoptera. Still, certain rare Carabidæ, Elateridæ, and Cerambycidæ are attracted by this bait, and the coleopterist should not entirely ignore this mode of collecting. There are a few other methods of trapping certain coleoptera. By laying out dead mammals, birds, fishes, snakes, etc., on suitable places and so that they are protected from dogs, rats, etc., the carrion-feeding Coleoptera can be found in great abundance, but a cleaner and less disagreeable method of obtaining them is to bury in the ground tin cans or glass jars so that the top is even with the surrounding ground and to bait them with pieces of meat, fried fish, boiled eggs, etc. Many Curculionidæ, Scolytidæ, and numerous other wood-inhabiting species can be successfully trapped in the following way: A number of branches, preferably of only one kind of tree, are cut and tied up into bundles of convenient size. The bundles are then laid on the ground in a shady place or firmly fastened on trunks of trees. When the cut branches begin to get dry they will attract many of these Coleoptera, which can then be readily collected by shaking the bundles out over the collecting cloth.

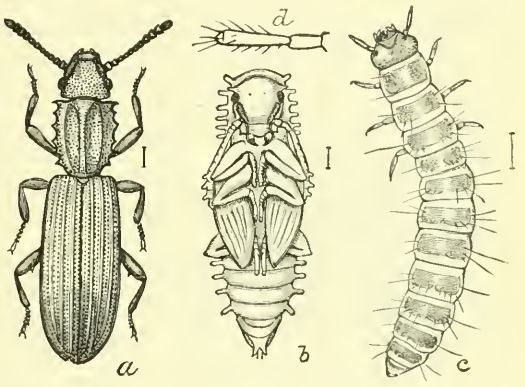

FIG. 123.—A CLAVICORN BEETLE, SILVANUS SURINAMENSIS: *a* BEETLE; *b*, PUPA; *c*, LARVA; *d*, ANTENNA OF SAME.

Freshets.—Freshets usually take place in springtime in most of our rivers and creeks, and furnish the means of obtaining a multitude of Coleoptera, among which there will be many species which can not, or only accidentally, be found otherwise. These freshets, sweeping over the low banks or inundating wide stretches of low land, carry with them all insects that have been caught by the inundation. Intermingled with, and usually clinging to, the various floating

débris, these insects are eventually washed ashore by the current at various points and the coleopterist should not miss this rare opportunity, but go out to the river bank at a time when the water is still rising, or at least when it has attained its highest point. Among, or on the washed up débris, a multitude of Coleoptera of various families can be found, and the specimens can either be gathered up on the spot or a quantity of the débris be put in sacks and taken home, where it can be examined more thoroughly and with greater leisure than out of doors. A day or so after the floods have receded the washed up specimens will have dispersed and only a few will remain in the débris for a longer period. Still more profitable than the spring floods are the summer freshets, because a larger and more diversified lot of Coleoptera is then brought down by the water. A similar opportunity for collecting is offered near the seashore if unusually high tides inundate the low marshes along the bayous and inlets.

Summer collecting.—During the latter part of spring and throughout the whole summer, when the vegetation is fully developed, every possible collecting method can be carried on with success, so that the beginner hardly knows what particular method to use. There are stones to be turned over; old logs, stumps, and hollow trees to be investigated; newly felled or wounded trees to be carefully inspected; here a spot favorable for sifting claims attention; promising meadows and low herbage in the woods invite the use of the sweeping net; living or dead branches of all sorts of trees and shrubs to be worked with the umbrella; the mud or gravel banks of ponds, lakes, rivers, and creeks afford excellent collecting places; the numerous aquatic beetles are to be collected in the water itself; the dung beetles to be extracted from their unsavory habitations; in the evening the electric and other lights are to be visited, the lightning beetles chased on meadows and in the woods, or the wingless but luminous females of some species of this family to be looked for on the ground, and the trees and shrubs are to be beaten after dark in search of May-beetles and other nocturnal leaf-feeding species which can not be obtained at daytime; and, finally, some of the rarest Scarabæidæ and some other species fly only late at night or again only before sunrise.

Fig. 124.—A Chrysomelid beetle, Octotoma plicatula.

In view of this embarrassing multitude of collecting opportunities in a good locality, the beginner is apt to be at a loss what course to pursue. Experience alone can teach here, and only an expert collector is able to decide, at a glance at the locality before him, what collecting method is likely to produce the best results, and his judgment will rarely be at fault.

It is impossible to go into details regarding the various collecting methods, just mentioned, and only a few general directions can be given regarding those methods which have not previously been alluded to.

Collecting under stones.—Turning over stones is a favorite method among beginners and yields chiefly Carabidæ, the larger Staphylinidæ, certain Curculionidæ, and a multitude of species of other families. Stones on very dry ground are productive only early in spring or in the fall, while those on moist ground, in the shade of woods, are good at all seasons. In the Alpine regions of our mountainous districts, especially above the timber line, collecting under stones becomes the most important method, and is especially favorable along the edges of snow fields. In often frequented localities the collector should carefully replace the stones, especially those under which he has found rare specimens. The neglect of this rule is one of the principal causes for certain rare species having become extinct in the vicinity of our cities.

Collecting in rotten stumps and logs.—Success in collecting in rotten stumps depends much upon the more or less advanced stage of decay as well as upon the situation of the log and upon the particular kind of wood. If the decay is very much advanced, neither the loose bark nor the interior of the log will harbor many Coleoptera excepting a multitude of *Passalus cornutus* and its larvæ. If the decay is less advanced, but if such log is exposed to the scorching rays of the sun, it will be far less productive than a log in a shady situation. The investigation of the bark of a favorably situated log in the right stage of decay does not need any special instruction, but the decayed wood itself should be pried off with a chisel or trowel, put in the sieve and sifted on the collecting cloth. This is the best way of obtaining the numerous species of rare Micro-Coleoptera of various families that inhabit such places. A "red rotten" oak or beech log is more favorable for this mode of collecting than a "white rotten" of the same or other kinds of trees.

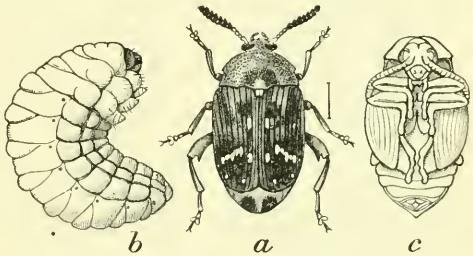

FIG. 125.—THE PEA WEEVIL, BRUCHUS PISORUM: *a*, BEETLE; *b*, LARVA; *c*, PUPA.

Collecting in dying or dead trees.—Dying or dead trees almost always harbor a large number of Coleoptera and offer an excellent collecting opportunity until the wood becomes thoroughly dry, which usually takes place in large trees two or three years after the death of the tree, and in less time with smaller ones. The bark of such trees is the best collecting place for Cucujidæ, Colydiidæ, Scolytidæ, Histeridæ, etc., and it will be found that the shady side

of the tree is more profitable than the side exposed to the sun. The numerous Buprestidæ, Elateridæ, Ptinidæ, Cerambycidæ, Melandryidæ, etc., which breed in the wood can be obtained only with difficulty. Some specimens may be cut out from their holes by a skillful use of the knife or hatchet; others (especially the Buprestidæ) may be found resting on or crawling over the trunk in the bright sunshine, while the more nocturnal species may be found on the tree toward evening or after dark, when, of course, a lantern must be used. A large proportion of the species living in the trunks of dead trees also breeds in the dead branches of otherwise healthy trees, from which they can be beaten into the umbrella, or where the use of the knife is more practicable than in the large trunks. The trunks of freshly felled trees attract numbers of Cerambycidæ and Buprestidæ and have to be carefully looked over, while the drying foliage of such trees affords an excellent opportunity for the use of the umbrella.

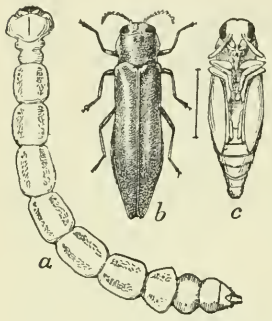

FIG. 126.—A BUPRESTID BEETLE, AGRILUS SINUATUS: *a*, LARVA; *b*, BEETLE; *c*, PUPA.

Beating living trees, shrubs, and vines.—The success of beating into the umbrella branches of living trees and shrubs depends on the particular kind of tree or shrub, on the condition and situation of these, and largely also upon the season. Pine trees are very productive from early in the spring to early in the summer, but much less so in midsummer and later on. Young oak trees or oak shrubs are much more preferred by the leaf-eating Coleoptera peculiar to this tree than the older trees. The beech, which, next to the oak, is the best tree for wood-boring species, harbors but few leaf-eating species. The leaves of the chestnut are also generally not attacked by Coleoptera; still a surprising number of species can be beaten from this tree when it is in blossom. There is not a single species of Coleoptera known to live in the wood or to feed on the leaves of the holly (*Ilex glabra*); still it will pay the coleopterist to beat this tree when it is in bloom. Trees, shrubs, and vines in the interior of unbroken forest districts are, as a rule, unproductive, while the edges of the woods, narrow strips of hedges, and especially solitary trees, are excellent collecting places. In the Rocky Mountains, especially in the more southern sections, long stretches of mountain slopes are occasionally perfectly bare of vegetation with the exception of a few solitary, sickly looking, and dwarfed trees, but every one of these is a veritable gold mine to the coleopterist with his umbrella.

FIG. 127.—A CARABID OR GROUND-BEETLE, CLIVINA IMPRESSIFRONS.

Sweeping.—The use of the beating net continues profitable from spring till fall, a different set of species appearing with each season. Low and swampy meadows, meadows on the slopes of mountains or surrounded by woods, low underbrush, and herbage in smaller patches of woods, are very good beating grounds. Dry and sandy meadows are less productive, but harbor usually a different set of species on account of the difference in the flora. Pastures and meadows much frequented by cattle and horses are much less productive, and where a large number of sheep are kept there is usually no chance for using the beating net, since neither grass nor specimens are left. The lawns in our parks and gardens are usually poor collecting ground on account of the limited variety of plants in such places; but the few species found there occur in enormous number of specimens. The endless stretches of our western prairies swarm at the right season (in June) with numerous Coleoptera (mostly Malachiidæ, Chrysomelidæ, Mordellidæ, Curculionidæ, etc.), provided prairie fires have not swept too frequently over the place. Fires and cattle produce a remarkable change in the flora and fauna of the prairies; many indigenous species disappear or become scarce and are replaced by a much smaller number of imported species.

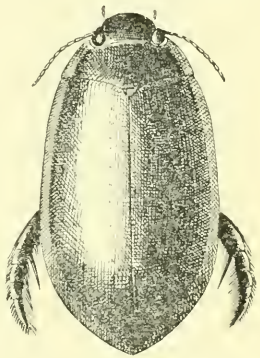

FIG. 128.—A WATER-BEETLE, DYTISCUS.

Sweeping may commence in the forenoon as soon as the dew has disappeared; it is less profitable in the heat of midday, but produces the best results late in the afternoon and more especially in the short interval from just before sunset until dark. At this time many rare Pselaphidæ and Scydmænidæ, species of the genera *Colon* and *Anisotoma*, and other small Silphidæ, can be beaten from the tips of grasses, all being species which can not, or only accidentally, be found during daytime, when they hide between the roots of plants.

Collecting on mud and gravel banks.—The mud or gravel banks of rivers, creeks, and stagnant bodies of water are inhabited, especially early in summer, with an astonishing multitude of Coleoptera. Countless specimens of smaller Carabidæ (*Dyschirius, Clivina, Bembidium, Tachys,* etc.) and Staphylinidæ (*Tachyusa, Philonthus, Actobius, Stenus, Lathrobium, Trogophlœus,* and many other genera) will be seen actively running over the mud or sand; many other specimens are hiding under the pebbles in company with other species (*Cryptohypnus, Georyssus,* etc.) or in little subterranean galleries (*Dyschirius, Bledius, Heterocerus*). All these beetles must be collected by picking them up with the fingers, an operation which, owing to the activity of the specimens, requires some little practice. The

beginner will at first crush or otherwise injure many of the delicate specimens, the capture of which is moreover by no means facilitated by the rapidity with which most of them are able to take wing. The collector must necessarily kneel down, and he must not mind getting covered with mud. A good device for driving these species out of their galleries or from their hiding places under stones or in cracks of the ground is to pour water over the banks, and this can in most cases be done with the hand. Larger stones and pieces of wood or bark lying on the bank are favorite hiding places of certain larger Carabidæ (*Nebria, Chlænius, Platynus,* etc.), and should of course be turned over. Finally, the moss growing on rocks and logs close to the water's edge, and in which, besides other beetles, some rare Staphylinidæ and the Byrrhid genus *Limnichus* can be found, should be scraped off and investigated on the collecting cloth or on the surface of a flat rock, if such be conveniently at hand.

FIG. 129.—A TIGER-BEETLE, CICINDELA LIMBATA.

Collecting aquatic beetles.—The fishing for water-beetles in deeper water by means of the water net has already been alluded to, but many species live in shallow brooks with stony or gravelly bottom, where the water net can not be used. The Dytiscidæ and Hydrophilidæ living in such places usually hide under stones, and can in most cases be easily picked up with the hand, or a little tin dipper or a spoon will be found convenient for catching them. The species of the family Parnidæ are found on the underside of rough stones or logs which are either partially or entirely submerged. They are more numerous, however, in the moss or among the roots of other plants that grow in the water. Such plants have to be pulled out and examined over the collecting cloth.

Collecting at the seashore and on sandy places.—A large number of species belonging to various families live exclusively in the vicinity of the ocean, some on the open beach, others along the inlets, bayous, or salt marshes, and still others on the dry sand dunes. The Cicindelæ are actively running or flying about close to the water's edge and have to be captured with the butterfly net. The remaining maritime species live hidden under the seaweed and other débris cast up by the waves, or in the sand (sometimes quite deep below the surface) beneath the débris or between the roots of the plants growing on the dunes. The majority of the maritime species do not appear before June (in the Middle States), but the collecting remains good until September.

In dry sandy places away from the seashore, the collecting at the roots of plants is especially to be recommended, and the plants, and more especially the bunches of coarse grasses usually growing in such places, should be pulled up and shaken out over the collecting cloth. This mode of collecting acquires a great importance in the arid regions of the West and Southwest, where, in the warm season, nearly all Coleoptera are hiding during daytime in the ground at the roots of plants.

Collecting dung beetles.—The collecting of the numerous species (Hydrophilidæ, Staphylinidæ, Histeridæ, Scarabæidæ, etc.) which live in the droppings of various animals is by no means an agreeable task. The collector should provide himself with a pointed stick and collecting tweezers, and must manage to pick up the specimens as best he can. The larger specimens are best collected in alcohol, while the more delicate species can be collected in a cleaner condition by removing the droppings and sifting the ground beneath the same. Some species hide deep in the ground beneath the droppings and have to be dug out. Summer freshets, when pasture lands are inundated, offer an excellent opportunity for collecting the dung-inhabiting species in a clean condition.

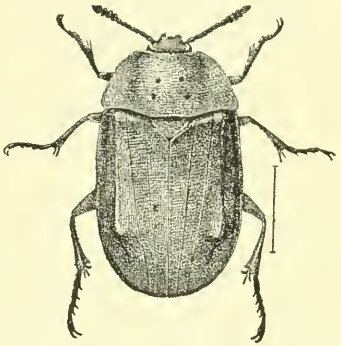

FIG. 130.—A SILPHID OR CARRION-BEETLE, SILPHA BITUBEROSA.

Night collecting.—The beating of trees and shrubs after dark is a good method of obtaining Lachnosternas and other species, and here the collector will do well to secure the assistance of a companion, who takes charge of the lantern and the collecting bottles, while the collector himself works the umbrella.

AUTUMN COLLECTING.—From the first of August the number of species gradually diminishes, but late in the summer or early in autumn quite a number of other species make their appearance, e. g., some Chrysomelidæ, Cerambycidæ, and many Meloidæ. Many of these frequent the blossoms of golden-rods, umbelliferous and other late-flowering plants. The fall is also the best season for collecting Coleoptera living in fungi. Although puff balls, toadstools, and the numerous fungi and molds growing on old trees, etc., furnish many species of Coleoptera also earlier in the season, yet most fungi, and more especially the toadstools, flourish best in the autumn, and consequently there is then the greatest abundance of certain species of Coleoptera. Decaying toadstools are especially rich, and should be sifted, and the collector should also not omit to examine the soil beneath them.

During the "Indian summer" there is usually a repetition of the "spring flight" of Coleoptera, though on a smaller scale, and collecting on the tops of fence posts and on whitewashed walls again becomes good. The first really sharp frost causes these late species to disappear, and winter collecting commences again.

LEPIDOPTERA.

The net for collecting Lepidoptera should be very light and of soft material, so as not to injure the specimens. Some lepidopterists prefer a net of gray or green material. Many species can be taken about flowers. It is usually better to take a butterfly in flight near the flower as it leaves or is about to alight, rather than when resting on the flower, for in the latter case one is apt to break off some pieces of the flower which, falling with the butterfly into the bottom of the net, may rub or tear the specimen. Avoid throwing a shadow upon the insect. When one is captured in the net, it should be clasped by the fingers from the outside with the wings folded together, and then by gently opening the net the mouth of the cyanide jar can be placed over it. Great care should be taken not to rub the specimen, as the scales are easily removed, leaving a blotch that ruins the specimen for the cabinet. Some collectors slightly pinch the thorax of the insect when captured. This prevents its fluttering too much in the cyanide jar. On a cloudy day, when flowers are swaying in the breeze, one may approach and place a cyanide bottle over a specimen without disturbing it. Moist spots by the roadside or in openings of woods are favorite localities for butterflies.

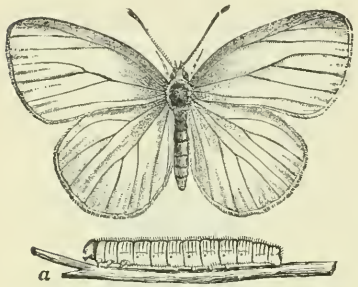

FIG. 131.—A BUTTERFLY, PONTIA OLERACEA, AND ITS CATERPILLAR.

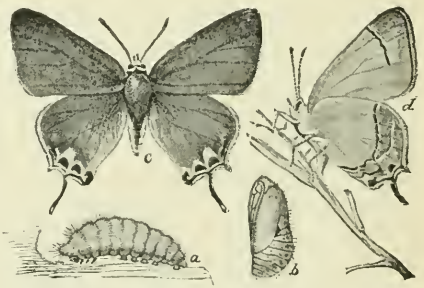

FIG. 132.—A BUTTERFLY, URANOTES MELINUS: *a*, CATERPILLAR; *b*, CHRYSALIS; *c*, *d*, BUTTERFLY.

It does not pay to chase butterflies, although if one misses a specimen at the first sweep of the net a swift, short run may sometimes bring success. "All things come to him who waits," provided he waits in a favorable spot.

Some butterflies are dimorphic; that is, the early spring brood is of a different appearance than the summer brood. In other species the males and the females are differently colored.

No other insects should be placed in the cyanide jar used to collect Lepidoptera, as the latter will be injured, and the other insects covered with scales. After the specimens are dead they should not remain longer in the cyanide bottle, else the yellow will turn to red. They should be pinned or papered in the field.

Many moths can be taken at night, and a trap light, as elsewhere described, is the best way to secure a lot of fine material. Sugaring, as described on page 47, is a prolific means of collecting moths. Many moths, as Catocalas and Geometrids, rest on the trunks of trees during the daytime. By carefully examining trees one can train the eyes to notice these insects when the casual collector would not see them. Mr. Merrick has devised a bottle with a trap spring cover attached to a pole for collecting Catocalas on trees above one's reach. It is described and figured in Entomological News, vol. 12, page 169.

FIG. 133.—AN ARCTIID MOTH, UTETHEISA BELLA.

The males of some of the larger moths are attracted to a female inclosed in a gauze cage, which may be exposed on warm, moist nights. In late summer and fall many moths rest upon dead leaves in the woods and fly up as one advances. One should be careful not to sweep up the leaves when one takes them, for the leaves will rub the specimens. Many of the smaller moths when captured in a net will partly walk and partly fly up the sides, and so may be taken in a small cyanide tube. The best way of obtaining perfect specimens of Lepidoptera is by rearing them. The caterpillars should be collected in a tin box, with a bit of their food plant, and taken home and placed in a breeding jar or cage. Directions for rearing are given elsewhere.

FIG. 134.—A CANKER-WORM MOTH, ALSOPHILA POMETARIA: *a*, MALE MOTH; *b*, FEMALE MOTH; *c*, *d*, ENLARGED PARTS.

Many moths visit flowers at night; by going to patches of bloom one may often secure varieties; the willow bloom in spring is very attractive; in fact, most flowers have some nocturnal visitants.

In collecting pupæ a trowel is one of the best tools. The best time is from August 15 on till November. They may be in soft soil or débris at base of trees, under dead leaves, among fallen pine needles, in rotten wood, in chinks of the bark of trees, or on the tree between fastened leaves. Arctiids (fig. 158) often pupate under the edge of stones, boards, etc. The pupæ should be disturbed as little as possible, and taken up with the leaves or bark to which they are attached. Pupæ should be placed in boxes with surroundings

similar to those of nature. They are usually lain back uppermost, but the position is not important.

In collecting caterpillars the first thing is to overcome the repugnance which most people have to handling these creatures. They are practically all harmless, and do not bite, nor sting with the horn near the tail. A few species, like the bristly green caterpillar of the Io moth, the saddle-back caterpillar (fig. 135), and the caterpillar of the brown-tail moth, produce a sort of rash on the hands. Although painful for a time, it soon disappears, and one acquaintance will fix these species in the mind, so that the others may be handled without fear. Caterpillars should be picked up carefully, so as not to injure them, but with some of the large forms it is necessary to work their legs loose from the plant, to which they sometimes hold with wonderful tenacity.

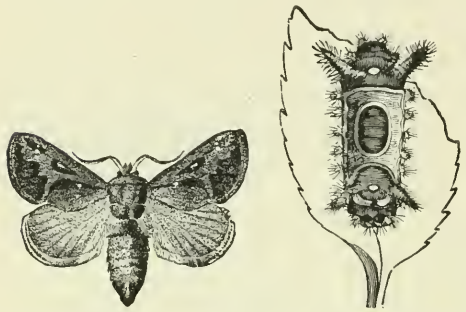

FIG. 135.—THE SADDLE-BACK, SIBINE STIMULEA: MOTH AND ITS STINGING CATERPILLAR.

Caterpillars may often be jarred from trees into the umbrella net before they have time to get a tight hold. After heavy storms one may find on the ground or at the bases of trees many caterpillars that have been beaten down by the rain and wind. Some of the caterpillars boring in stems of plants may be located by cautiously bending suspected stems in different directions.

FIG. 136.—THE BAGWORM, THYRIDOPTERYX EPHEMERÆFORMIS, FEMALE.

Early morning and late afternoon are the best times for discovering caterpillars. Many can be located by their droppings, or excrement, others by the partially eaten leaves. Some feed mostly at night, descending to the ground and hiding in the soil at base of the plant during the daytime. Many are protectively colored, and one must scrutinize the leaves and twigs carefully to find them. In the case of the solitary larvæ, when one has been taken, other plants of the same kind in the vicinity will possibly furnish other specimens. Whenever one finds a species in abundance, a goodly supply should be taken along, as some may be parasitized, and others may die before reaching the adult stage. Mr. Rowley often traps Catocala larvæ by leaning a pair of shingles against a tree. Bits of boards laid on the ground will offer concealment to many Noctuid caterpillars; lettuce and clover are also good baits.

Often one may find eggs attached to leaves, and from these one may rear and observe all the stages of the insect. A better way is to save captured gravid females and place them in a cage, with a probable food plant as an inducement to deposit their eggs. A bottomless barrel or nail keg placed over a plant and the top covered with mosquito netting makes a good cage. Various other cages are described in the chapter on rearing.

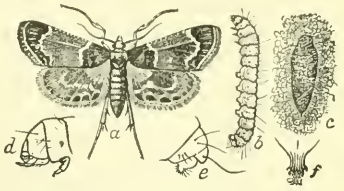

FIG. 137.—A PYRALID MOTH, PYRALIS FARINALIS: *a*, MOTH; *b*, CATERPILLAR; *c*, PUPA; *d*, *e*, *f*, DETAILS.

The Microlepidoptera, whose caterpillars mine or roll leaves, may be easily reared from injured leaves. Many Microlepidoptera are to be found flying at twilight over fields, especially at the edge of woods. A small light net will be useful in securing these. Many others rest on the bark of trees; these are taken by a small cyanide vial. Formerly most of the microlepidopterists collected these insects in pill boxes, killing them with a drop of chloroform on a pinhole in the box. Now, however, most prefer to collect them in small vials containing chloroform or cyanide. A great majority of these small moths are attracted to lights, and one may take hundreds of specimens and many species in one evening.

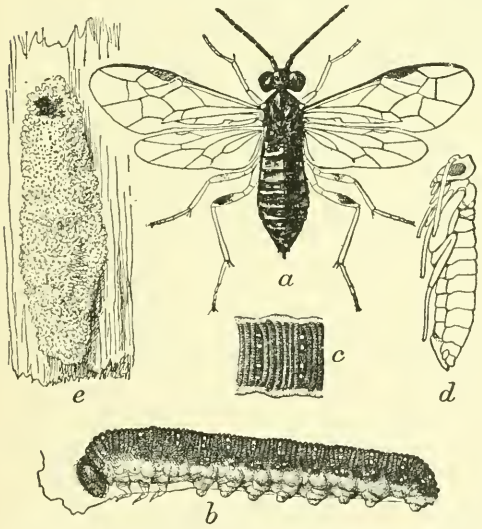

FIG. 138.—A SAWFLY, EMPHYTUS CANADENSIS: *a*, ADULT; *b*, LARVA; *c*, ENLARGED SEGMENT OF LARVA; *d*, PUPA; *e*, COCOON.

If one can not spread the Micros as soon as dead, they should be pinned (with micro-pins) in a small box, carried along for that purpose. After pinning, one should blow the wings lightly from behind, so as to separate the tips of the wings. If one expects to spread the specimens upon reaching home, the cork of the small pinning box may be moistened; this will keep the Micros from drying out.

Mr. Kearfott gathers the larvæ of the Microlepidoptera in glass vials, 3½ and 5½ inches long. In searching for these larvæ one must look out for their work; a crumpled leaf, a brown spot, or a withered shoot indicates the presence of the caterpillars. One must not try

to remove the larva, but break off the abnormal part of plant and put it in the vial, keeping track by labels of the name of the plant.

In rearing material one should be careful to save for the cabinet some specimens of the larvæ, as well as the pupæ or pupal skins. These should be so labeled as to be readily connected with the reared insect.

HYMENOPTERA.

A great variety of bees and wasps may be gathered from flowers. A small or midget net suffices for most species, but the larger Pompilidæ (fig. 155) and Sphegidæ (fig. 140) are better caught in a large net. It is sometimes difficult to secure from the net a large stinging Pompilid. A few swift strokes of the net across the knee will assist in stunning the specimen without breaking it. Many bees can be picked from flowers with a forceps, or even with the fingers, as but few species can sting sufficiently to hurt, and one must expect an occasional thrust when collecting Aculeates. The specimens collected from each species of flower should be kept in separate cyanide bottles The larger Parasitica are to be found on shrubbery, in rather open woods or near the edge of woods, and most are easily caught with a net. Smaller forms will be found by sweeping herbage, and in the winter time many will be found by sifting moss, fallen leaves, and rubbish. Upon dead trees one may often find some parasitic Hymenoptera which are seeking to oviposit on the various larvæ in the trees. On warm, sunshiny days of spring one can sometimes find a variety of small forms on the fresh foliage of oak trees.

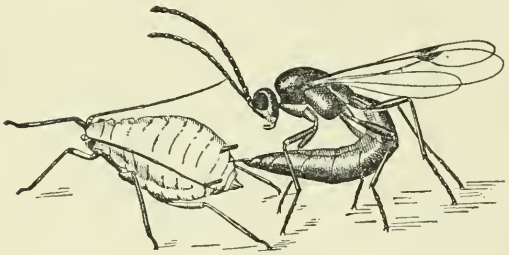

FIG. 139.—LYSIPHLEBUS DEPOSITING ITS EGGS IN THE BODY OF A GRAIN-APHIS.

The gall insects (fig. 70) may be reared from the mature galls, but it should be remembered that galls harbor many other insects than the makers, so that any species reared from a gall is not necessarily the maker of that gall. Moreover, some issue a year or more after the gall is mature. The sawflies (fig. 138) are chiefly found in the spring or early summer in shrubbery, tall herbage, and open groves, and on the young leaves of trees. They fall readily into the net, often playing 'possum. Any one who is rearing Lepidoptera and other insects should save the Hymenoptera that issue therefrom, giving each a label with name of host. Sandy spots furnish an opportunity to secure many fossorial forms. By waiting a bit around the holes and

carefully watching the collector may obtain some of the parasitic species. Ants (fig. 159) can be secured anywhere, but it is better to get at the nests and so secure the different forms at one time. All the specimens from one nest should bear a number, as "Nest 16." They may be collected in alcohol and mounted up as desired. The social wasps and bumblebees may be gathered from the nests by visiting them at nightfall and introducing chloroform, or carbon bisulphide for those in the ground. One may thus gather all the different forms, which are not as yet known for many of our species of these insects.

The Micro-Hymenoptera are sometimes collected in alcohol, especially those obtained in sifting. These can be prepared for mounting, Mr. Crawford says, by removing them from the alcohol and placing

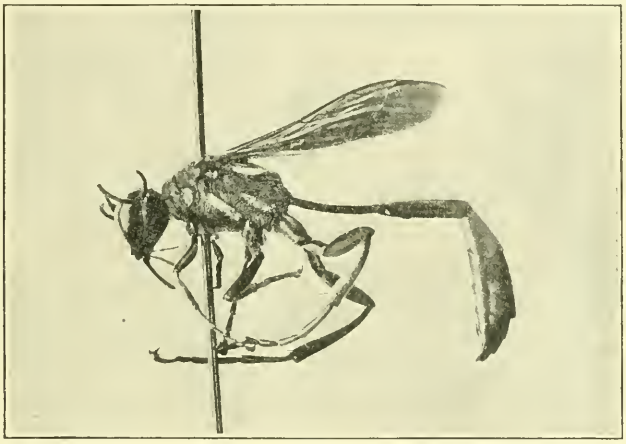

FIG. 140.—A FOSSORIAL WASP, AMMOPHILA NIGRICANS.

them in chloroform for a few minutes, and then out on blotting paper. In many cases the genitalia of Hymenoptera are of value in determining the species. If the specimen is gently squeezed near the tip of the body the genitalia will sometimes be extruded. Otherwise they will have to be removed with a pair of fine scissors and scalpel and mounted on a slide or on a bit of cardboard attached to the pin. The nests and galls of Hymenoptera should be collected whenever possible. The galls may be pinned in the boxes, but a better way is to put them in flat pasteboard boxes of a size suitable to be arranged in rows in the box or drawer, with a label on the upper edge of each box indicating the contents. Casts of holes may be obtained by pouring into them mixtures of cement or plaster of Paris.

Although many of the brightly colored flies (fig. 156) occur on flowers, more different kinds can be obtained by sweeping herbage. In the latter case after one has taken a few strokes the end of the net should be twisted a little, and the tip with its contents placed in a large cyanide jar for fifteen or twenty minutes. On removal the insects will be dead, and one can pick them out leisurely. For flower collecting a small or midget net is very handy. Many species will be found in open groves or the borders of woods, on the trunks of trees, and on the leaves and shrubs. For these a light sweeping net is the best, one that can be handled with great rapidity. The gall-making species may be reared from the mature galls, and also those whose larvæ occur in fungi and under the bark of trees.

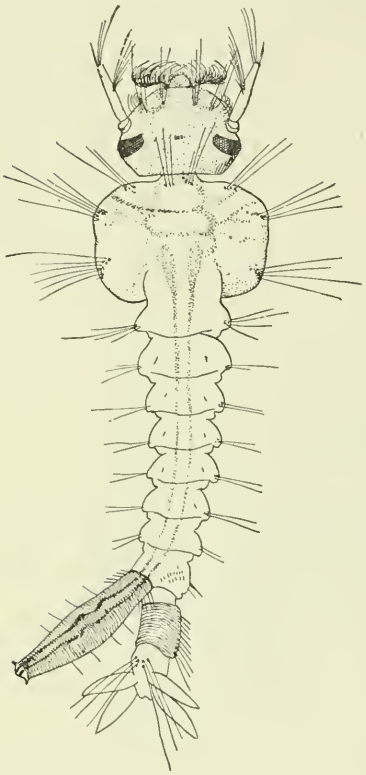

FIG. 141.—THE LARVA OF A MOSQUITO, CULEX.

Diptera suffer more than most insects from shaking about in the bottle or against heavier insects. Therefore it is well to collect them separate from other insects, and to have in the cyanide bottle plenty of crumpled strips of blotting or other soft paper. In many cases, especially with the long-legged kinds, they should be pinned in the field soon after capture. Many of the gall-flies (Cecidomyiids) are preserved mounted in balsam on slides. Doctor Dyar prefers to mount mosquitoes on points, but they are as well on micro-pins as a double mount. Many bristly Diptera should be pinned a little to the right of the center of the thorax, for a pin through the middle will destroy the bristles in the middle which are of value in classification. In the case of predaceous species the prey when observed should be put on the same pin as its captor.

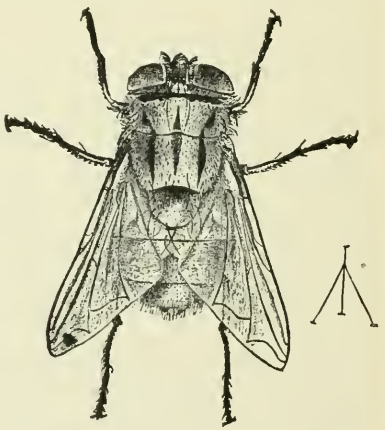

FIG. 142.—THE SCREW-WORM FLY, COMPSOMYIA MACELLARIA.

With reared specimens it is often customary to mount the pupal skin on a bit of cardboard attached to the pin bearing the adult fly. The life histories of but few Diptera are known, and this is an inviting field for investigations.

Many horseflies (fig. 143) can be collected from a herd of cattle. With some hairy flies, like Bombyliidæ, it is better to kill them with chloroform, or pin them in the net and kill them later, for they lose many of their hairs in the ordinary cyanide bottle.

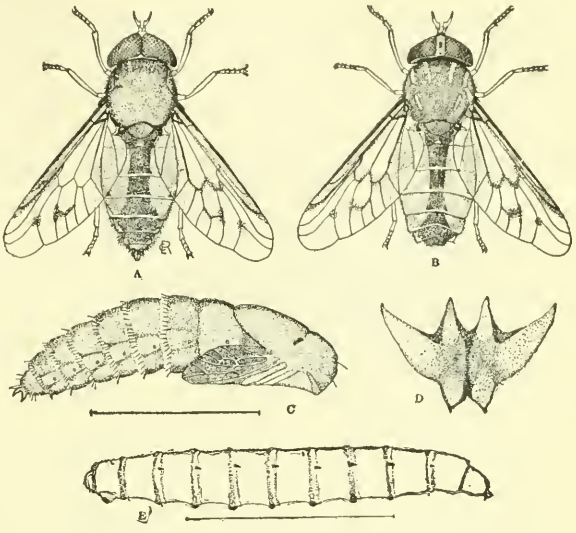

FIG. 143.—A HORSEFLY, TABANUS LASIOPHTHALMUS: *a*, MALE; *b*, FEMALE; *c*, PUPA; *d*, TAIL OF SAME; *e*, LARVA.

HEMIPTERA–HETEROPTERA.

The habits of the Hemiptera–Heteroptera are in many ways similar to those of the Coleoptera, and one who collects beetles will come across a great variety of bugs. A number are found on the ground, others in or on the water, some on the bark and twigs of trees, many species on the leaves of trees and shrubs, under stones, among fallen leaves, and in moss. A few are obtained by sweeping, and most of them by looking in likely situations, and the forceps and empty vial are the most useful instruments. A number may be taken with the umbrella net. Many of the aquatics, and some of the Reduviids (fig. 144), come to light. Many species are restricted to one or a few food plants, so that food-plant labels should be pinned with the specimen. When one takes a number of Tingitidæ or Aradidæ it is well to mount a few specimens upside down, as the venter is of importance in classification. Frequently it is necessary to mount the wings and heads as dry mounts on slides for microscopic study.

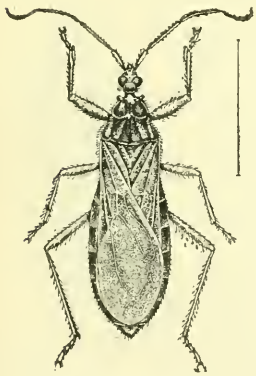

FIG. 144.—A "KISSING BUG," REDUVIUS PERSONATUS.

Many Heteroptera hibernate in the adult condition under the loose bark of dead trees, on the ground under fallen leaves, or under pieces of wood in fields. By searching in such places late in the autumn or early in spring one may obtain many varieties.

For the large family of Capsidæ (fig. 21) June is the best season. Sweeping herbage, meadows, and the foliage of trees will bring many of these fragile insects into the net.

FIG. 145.—A WATER BOATMAN, NOTONECTA IRRORATA.

The best times of the year to collect aquatic Hemiptera (figs. 145, 146), Mr. Bueno says, are the spring and autumn. Mr. Bueno uses a couple of water nets, cyanide bottles of several sizes, tin boxes for living specimens, and a pair of rubber boots. These insects should not be collected in alcohol, except for anatomical purposes, and should be mounted as soon as possible. The water-bugs can be easily kept in aquaria, but since many are predaceous one can keep only a few in each vessel.

HEMIPTERA—HOMOPTERA.

The Homoptera may be obtained by sweeping herbage or beating trees. Many of them are mounted on points, but some may be pinned with micro-pins as double mounts. Some species occur commonly in a short-winged or brachypterous condition; one should look carefully in the proper situations for the macropterous or long-winged specimens. It is well to have one or two specimens of each species with the wings spread, as these organs are sometimes colored and the dorsum of the abdomen has bright markings. The plant-lice (fig. 26) may be collected in alcohol, but are better brought home in tin boxes and mounted in balsam on slides. It is well to take note of their colors before killing them. It is necessary to obtain the various forms and stages, so that the same plant should be visited at different dates; some species migrate to other plants in the latter part of the season, so that one will have to search around to find this alternate food plant.

FIG. 146.—A WATER-BUG, NEPA APICULATA.

The scale insects (fig. 149) should be collected with a bit of twig or leaf on which they occur and pinned in the collection. A better way is to put them in flat pasteboard boxes of a size to fit well in rows in the cabinet, and then a label pasted on the upper edge of each box indicating its contents. Mr. Sanders has prepared the following account of his method of mounting scale insects on slides:

The greatest care in manipulation is necessary to secure a good mount of a scale insect. Various simple and complex methods have been used by students of Coccidæ, but the media most generally used for mounting are glycerin jelly and Canada balsam. After a

long trial glycerin mounts have proved very unsatisfactory, even when carefully mounted and ringed with a supposedly impervious cement.

Diaspine scales.—Diaspine scales are boiled in caustic potash, the method of boiling varying from a few seconds to half a minute for the very strongly chitinized species. Specimens thus softened and partially cleared are transferred from the tube directly to a microscope slide and carefully washed with warm water with the aid of a pipette. Washings with 95 per cent alcohol follow, and the scales are then floated to the center of the slide and arranged in a line, with the pygidia pointing in one direction; after which the alcohol is removed with bibulous paper. Before the alcohol is entirely evaporated a small drop of oil of cloves is applied and slightly heated to drive off the bubbles of air and to cause the oil of cloves to penetrate the specimens. The oil of cloves having been removed, a very small drop of balsam is added and a clean cover glass is applied and held in place with a steel clip while the slide is heated for a few seconds over an alcohol lamp to dry the balsam. If care is used, the balsam can be quickly dried, so that upon cooling it is perfectly hard. Fifteen to twenty minutes are ordinarily needed for such preparation.

FIG. 147.—ONE OF THE FULGORIDÆ, POIOCERA FULIGINOSA.

FIG. 148.—ONE OF THE PSYLLIDÆ, PSYLLA PYRICOLA.

Nondiaspine scales.—In mounting the soft-bodied scales various methods are necessary for clearing the insects on account of the remarkably diverse coverings which they produce. With the lac insects and species of the genus *Ceroplastes* it is often necessary to boil the specimens in chloroform or acetic acid to remove the wax. Mealy-bugs and Lecaniums can be immediately removed to the potassium hydroxide and boiled similarly to the diaspine scales. However, it is frequently necessary to boil the specimens for a long period, and also to prick holes through the body wall to allow the escape of the body contents. After boiling, the specimens are washed in warm water, and dehydrated with two or three grades of alcohol, then arranged upon a slide, and clove oil or xylol applied preparatory to mounting in the usual way in Canada balsam In mounting very convex species it is frequently necessary to slit the

margin of the scales so that they will lie flat upon the slides. Great care must be exercised to secure a good mount of such soft-bodied scales as the mealy-bugs, it being necessary to float the specimens onto the slide and handle them with extreme care to prevent them from curling and folding. Canada balsam having been placed on the insect and the cover glass applied, the slide is heated as in mounting the diaspine scales.

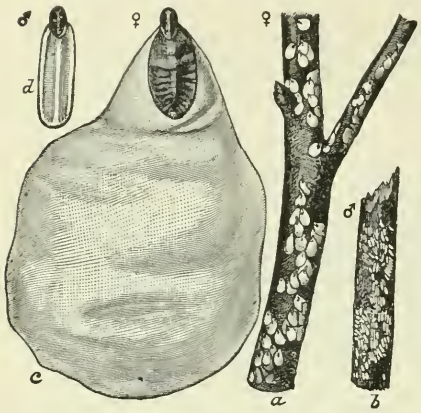

FIG. 149.—A SCALE INSECT, CHIONASPIS FURFURUS: *a*, FEMALE SCALES; *b*, MALE SCALES; *c*, FEMALE ENLARGED; *d*, MALE ENLARGED.

Sometimes it is desirable to stain the specimens. This should be done while the insect is immersed in alcohol, or at least before xylol or clove oil is applied. One of the very best stains which has been used for this purpose is ordinary carmine ink, which can be used in conjunction with weak alcohol.

Another method of mounting the insects in situ for superficial examination was originated by Prof. Herbert Osborn, of the Ohio State University. Diaspine scales or any flat scale insects when perfectly dry can be readily mounted between two strips of mica of the same dimensions as the ordinary microscope slide with the passe-partout method—i. e., the edges of the mica are sealed by means of gummed strips. Specimens mounted in this way are available for easy examination, and can be filed along with the ordinary slide mounts.

The Anoplura, or lice, may be collected on the domestic and wild animals and should always be mounted in balsam on slides.

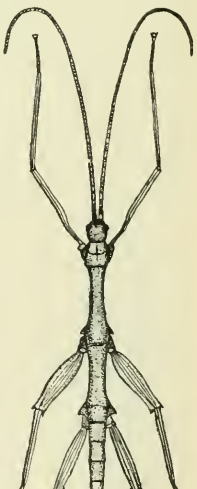

FIG. 150.—A WALKING-STICK, MEGAPHASMA DENTICRUS.

ORTHOPTERA.

A large number of Orthoptera can be obtained by sweeping meadows and herbage. Many of the crickets occur on the ground; others are to be found on shrubbery. Roaches (fig. 11) are found under loose bark of trees, among rotten logs and fallen leaves. Most of them found are young, but by looking at different times one will find the winged ones, usually in May or June. Their egg-cases, or ootheca, should be saved, as that of each species has a characteristic

appearance. Some Orthoptera occur on trees; these are frequently attracted to lights. The grouse-locusts (*Tettix*) are most common on moist, dark soil. The more active specimens resting on the ground may be taken by suddenly placing the net over them. If they do not readily fly up, the net may be pressed on the ground and one can feel the specimen.

Few, if any, insects reflect the nature of their surroundings better than the Orthoptera. One can tell by the specimen whether it was taken on light or dark soil, in a wet or a dry situation, in the shade or exposed to the sun.

So responsive are their external tissues to their environment that it is among the Orthoptera we find the most remarkable examples of protective resemblance. They are therefore the most convenient group for ecological studies, and for this purpose a label indicating the nature of the locality should be pinned with each specimen.

FIG. 151.—A GRASSHOPPER, PSINIDIA AMPHICORNIS.

The large, fat-bodied Orthoptera often shrink so much in the cabinet that many orthopterists slit the base of the venter with a pair of fine scissors, remove the abdominal contents, and stuff with cotton, taking care, of course, not to distend the body.

NEUROPTEROIDS.

The Odonata, or dragonflies (fig. 9), can usually be found flying over ponds or streams; others will be taken in openings or paths of woodlands. Many of them have the habit of returning over and over again to the same stick or twig to rest, so that by waiting near by one is apt to get a good chance to capture the insect. For these insects a light net is necessary and a fairly long handle. These insects are expert dodgers, and one must strike quickly, and a stroke from behind is fully as apt to take the specimen as one from in front. Sometimes in the early morning one can find the nymphs on grasses near

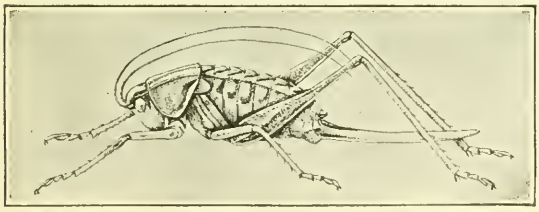

FIG. 152.—A WESTERN CRICKET, OF THE FAMILY LOCUSTIDÆ, STEIROXYS TRILINEATA.

the pond, transforming to the adult. If these are taken and kept alive for a day, they will attain their full coloration. Each specimen should have a hog bristle inserted into it from the head through to near tip of abdomen to keep the specimen straight and to prevent the loss of abdomen and head. Straight pieces of broom from a whisk broom may be used for the larger forms.

Many other Neuroptera, as caddiceflies, stoneflies, and mayflies, are attracted to lights placed near ponds and streams. During the day these insects often rest under the leaves of shrubbery near the water. The Psocidæ are most common on the trunks of trees or on fences in summer and early fall. By searching carefully over the bark of oak, tulip, chestnut, maple, and other trees one will nearly always find a few of them. One should have a supply of small, empty vials, placing one over each specimen. The Psocid may be made to fly into the vial by tickling it with a bit of grass or a toothpick pushed under the edge of the vial. From the vial they may be shaken into a small cyanide bottle in which are crumpled strips of soft paper. They should be pinned with micro-pins as soon as possible after death. The mayflies are so fragile that many are better preserved in alcohol. When one finds the subimago of these insects, it may be kept in a wooden box until it molts to the adult. It is useful to save one or two subimagoes of each species, since these have a characteristic appearance. Caddiceflies (fig. 163, *a*) can be obtained by sweeping the foliage of bushes and trees near streams and ponds. All of the Neuropteroids can be collected and shipped in envelopes just as Lepidoptera.

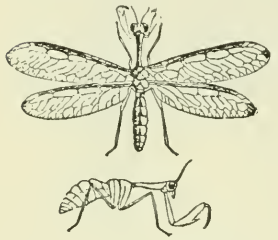

FIG. 153.—A MANTISPA, WITH SIDE VIEW BENEATH. (FROM PACKARD.)

Mr. Bignell preserved the colors of dragonflies as follows:

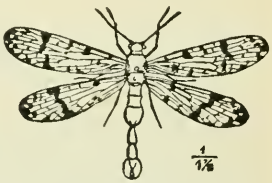

FIG. 154.—A PANORPA, OR SCORPIONFLY. (FROM PACKARD.)

Directly after death, clean out the contents of the thorax and abdomen. To do this, obtain a long darning needle, thread it with a short piece of fine cotton, tie the ends together so as to form a loop; sling into this loop one or more strands of cotton or silk, according to the size of the insect. For the largest, four strands may be used. This would give eight threads in the thorax and abdomen, taking care to select the cotton or silk of the predominant color of the fly. Then pass the needle into the fly, directly under the head, through the thorax and abdomen, pulling the cotton or whatever is used through the body until it comes out quite clean. Then slide the abdomen up a little, cut off the end of the material used, pull the abdomen down to cover it, then cut off close under the head, leaving the remainder in the body. The fly will then be ready for setting.

Some have used artificial heat to preserve the coloring of dragonflies.

SPECIAL KINDS OF COLLECTING.

It is of great interest to any observer to find out what occurs in a certain place or under certain conditions. For example, the insects that are associated with ants, that are to be reared from fungi, that occur along the seashore or in caves, or to be taken from a certain kind of flower. This group or ecological collecting is of increasing biological interest, since it shows what insects are associated with each other, compete with each other, and may influence each other's life. Many prominent biological questions are opened by this collecting, such as isolation of allied species. Some of the principal lines of this kind of collecting are noted below. All specimens collected under like surroundings should bear a label indicating the fact.

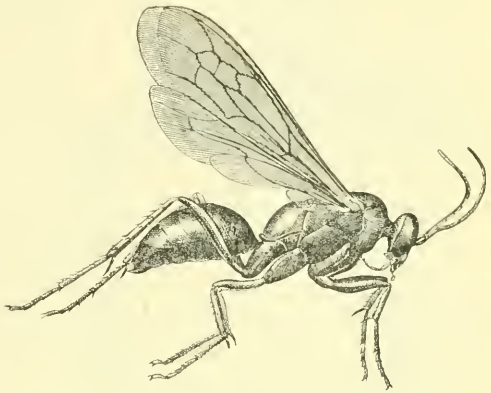

FIG. 155.—ONE OF THE POMPILID WASPS, PRIOCNEMIS.

Flowers.—It will soon be noted by any one observing insects that certain species prefer certain flowers. This is especially noticeable among bees, but many Diptera (fig. 156) also show such preference. Other insects prefer flowers of a certain color. By watching certain flowers year after year one will pick up many rare forms that would not have been captured by desultory collecting, and at the same time gather many facts about habits and occurrence of insects that are as yet far too little known to entomologists. For taking insects from flowers one should not use a large or heavy net. It is apt to break the blossoms so that they will attract but few insects on following days, and a large net is apt to frighten away other insects

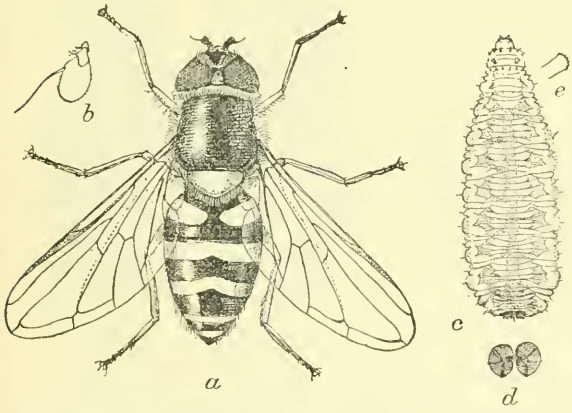

FIG. 156.—ONE OF THE SYRPHIDÆ, SYRPHUS RIBESI: *a*, FLY; *b*, ANTENNA; *c*, LARVA; *d*, *e*, DETAILS.

from nearby flowers. A midget net will be found useful for much of this collecting. Many species of wasps and bees can be taken from flowers with a fine forceps. Others can be captured with the fingers, as few bees can sting severely. The captures from each species of flower should be kept in separate cyanide bottles, and on pinning should have a label with the name of the plant.

FIG. 157.—A TACHINA FLY, TRICHOPODA PENNIPES.

Soil collections.—It has long been noted that sandy places, such as sea beaches, are inhabited by a peculiar set of insects; a few of each order. These are modified to suit their surroundings, often protectively colored, of strong flight, or resistant to submersion in sea water. Other kinds of soils have also a peculiar fauna, although hardly as striking as that of sandy beaches. A low, wet spot with black soil will have its peculiar forms of grasshoppers, Hemiptera, Coleoptera, etc. In this kind of collecting one must often get on his knees, and, bending close to the ground, watch for any moving object as he carefully pushes aside the leaves and sticks. A fine forceps is the best instrument to pick insects from such situations.

Fungi.—The various fungi that are so abundant in our woods in summer

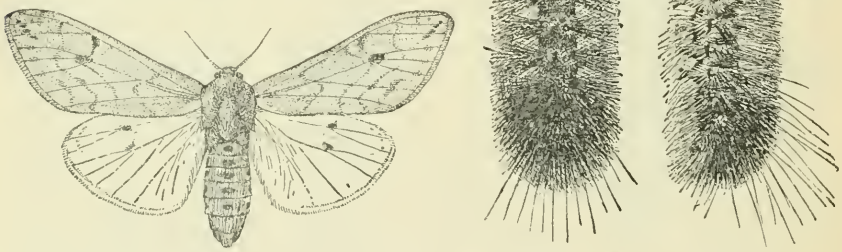

FIG. 158.—THE SALTMARSH MOTH, ISIA ISABELLA, FAMILY ARCTIDÆ: MOTH AND CATERPILLAR.

and autumn conceal hosts of insects. Until one systematically gathers and breeds them one has no idea of the wealth of material. Fungi in different conditions afford food for different insects. Nowadays it is quite possible to have the fungi identified by specialists in mycology, so that one may label the specimens with the name of the fungus from which it was bred. The fungus, if moist, should

be placed in a tin box, and, if necessary, braced with twigs so that it will not shake about; if a dry species, it may be wrapped up closely in a piece of stout tissue paper and carried home in any kind of box. Some fungi require wet or a moist atmosphere for the development of these insects, and these should be taken up with some soil about them and placed in a jar or cage where the soil can be kept wet. Other fungi, particularly those on the bark of trees, may be kept in a dry jar or jelly glass until all the insects have issued from them. In many cases the larvæ pupate in the soil under the fungus, and so it is useful, especially with beetle larvæ, to have soil under the fungus in the breeding cage.

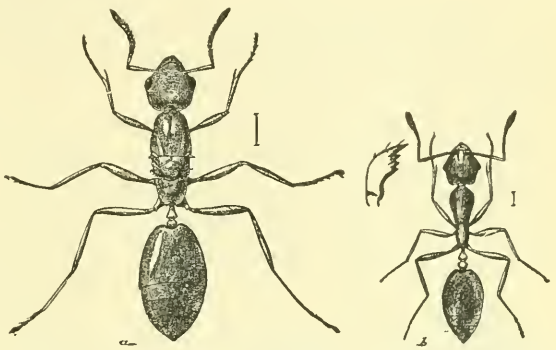

FIG. 159.—AN ANT, MONOMORIUM PHARAONIS: *a*, FEMALE; *b*, WORKER.

Ants' nests.—Ants' nests harbor many curious insects outside of the rightful owners. These insects are known as "Myrmecophiles." Some are tolerated or even fostered by the ants; others are their unwelcome guests; they are rats, and mice, and fleas. To secure these insects one must examine the nest and sift its material. Many of the ant guests are beetles, and these have been discussed by Mr. Schwarz. The nests of white ants or termites also have their guests. These are known as "Termitophiles."

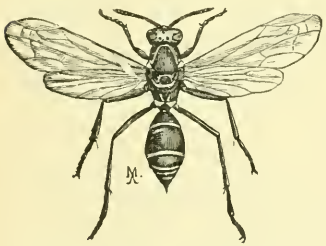

FIG. 160.—A WASP OF THE FAMILY VESPIDÆ, POLISTES BELLICOSUS.

Wasps and bees.—Many wasps (fig. 160) and bees nest in colonies, and if these colonies are large it will be soon noted that a number of other insects can be found around the holes or reared from the nest. When one discovers such a colony he should visit it several times and secure the numerous insects that are associated with the wasps and bees.

Galls.—Many insects can be reared from galls, aside from the gall-makers, there being numerous insects called "inquilines" which occur with them. Beetles and Lepidoptera are sometimes obtained from galls made by other insects.

Moss.—Many minute insects find in that tiny forest we call moss a most hospitable shelter. Numbers of mites, small spiders, and spring tails, many beetles, and a great variety of Hemiptera as well as some delicate flies are here at home. In the winter time there

are also many of the Micro-Hymenoptera. The best way to get at this hidden fauna is by sifting the material through a sieve net, but one can obtain many specimens and learn a great deal about the habits of these pygmies by getting down on his knees or lying prone and picking away the moss. These specimens should be labeled as from moss, and when possible one should give the name of the moss.

Nests.—A considerable number of insects occur in the nests of birds, moles, mice, and other animals. The material can be sifted, and sometimes, if kept in a jar, one may breed a number of these insects.

Excrement.—The droppings of cattle are rich in insect inhabitants. Many of them breed or feed in the material, while quite a number are predaceous and feed on the other insects. The manure may be placed in a pail of water and the insect inhabitants will float to the surface. Some of the species burrow in the soil under the manure, and if one wishes to rear them it is necessary to take up this as well as the manure to the breeding cage.

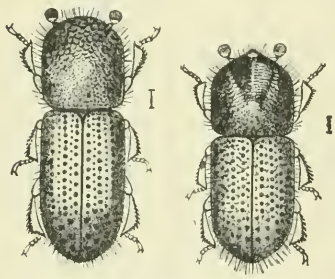

FIG. 161.—A SCOLYTID OR ENGRAVER-BEETLE, XYLEBORUS PERFORANS, MALE AND FEMALE.

Dead animals.—Many beetles and flies are attracted to carrion and the parasitic Hymenoptera to oviposit in their larvæ. One visit will not be enough, as later one may find different species from those captured on the first trip. Many species that occur in carrion may be trapped by placing a few bits of wood or bark on the ground near the body. The specimens if soiled may be cleaned in benzine or gasoline.

Forest insects.—The collection and study of insects injurious to forest trees has developed new tools and methods; these are briefly summarized by Doctor Hopkins as follows:

The equipment for collecting specimens need not be expensive or elaborate. The necessaries are: A hatchet or light ax, carried in a scabbard, which may be fastened to a stout belt; a hunting coat, or an ordinary sack coat, with many pockets; a supply of collecting vials of various sizes, fitted with the best cork stoppers; a small bottle of alcohol; a medium and a small cyanide bottle; tweezers; camel's hair brushes; a stout knife with small and large blades; a small saw; a net, and umbrella; and last, but not least important, a notebook and pencil. With this equipment, or such part of it as is required for the special kinds of specimens desired, a good observer can go out in the woods any day in the year and find plenty of material.

The best places to collect species infesting wood and bark are along the edge of the woods, or where trees have been girdled or felled a

few months previous. Here one will usually find in the bark of the roots, stumps, main stems, tops, branches, and twigs different stages of many species of barkbeetles and bark-inhabiting larvæ, together with their natural enemies and associates; and the wood will yield many more.

Lumbering regions and sawmill yards are especially prolific in specimens at all times, as are also broken branches, individual trees, and groups injured or killed by insects, felled by storm, or otherwise rendered attractive to insects. During the spring, summer, and fall the foliage will yield specimens almost unlimited in number and variety. But one should remember, as has already been indicated, that it is not the number and variety, but those of most importance that are to be sought out, noted, collected, and studied. It is often better to spend a day in the diligent search for all that can be found in or on a single tree, or in observing and recording in the notebook all that can be found out about a single species, than merely to collect hundreds of specimens or many species without careful records.

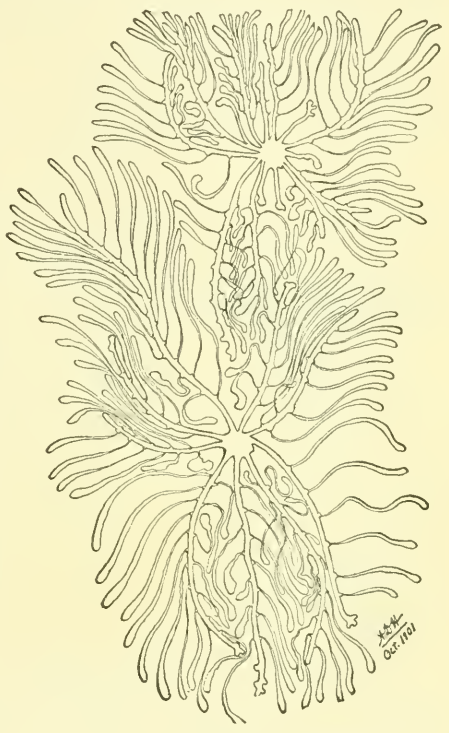

FIG. 162.—GALLERIES OF A SCOLYTID BEETLE, PITYOGENES CARINICEPS.

Indeed, the proper recording of what one sees at the time the observations are made is of the greatest importance, and is the one thing the student should practice more, perhaps, than anything else.

The collector should be constantly on the lookout for the natural enemies of the principal injurious species. One class of the enemies of insects consists of parasitic Hymenoptera, Diptera, etc., found in the adult, larval, or pupal stage, associated with their host, the larvæ as external or internal feeders on the larvæ, pupæ, or adults of the injurious species, and the adult parasites ovipositing on or in the victims, or in the bark or other infested parts of the plant. The insect enemies of the other class are predatory species of Coleoptera, Hemiptera, Hymenoptera, and other kinds of insects which attack and kill their victims, and either devour them or suck out the liquid parts of their bodies. There are also insect diseases which may be indicated by a white powdery substance on the bodies

of the dead insects, and whenever numbers of examples are found to be dead or dying, specimens should be collected and submitted without delay to some specialist on this class of diseases.

The specimens of work of insects should have the surplus parts removed, and should be labeled and stored where they will be readily accessible for future reference. Broad shallow drawers or trays are convenient for the smaller wood and bark specimens, while wood or heavy paper boxes serve for larger ones. Common florists' paper boxes, which are shipped flat ready to be made up, are excellent for storing the classified material.

Every individual specimen, mounted set of alcoholic specimens, specimens of work, etc., should bear the note number referring to it in the notebook.

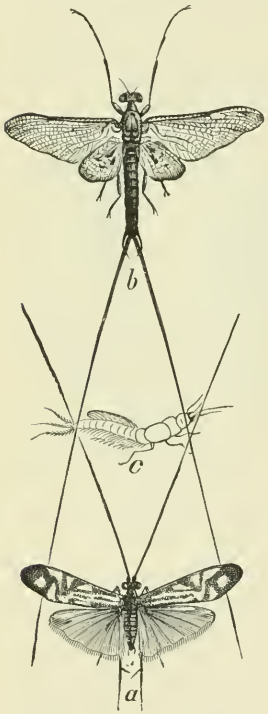

FIG. 163.—*a*, A CADDICEFLY, MACRONEMA ZEBRATUM; *b*, A MAYFLY, HEXAGENIA BILINEATA; *c*, ITS LARVA.

Aquatic collecting.—By watching a certain pond or stream for several years one will find it full of insect life. The number of species there associated together in their different stages is remarkable. Doctor Needham has devised a method of gathering these insects from a limited area of the water. He erects a tent of white muslin over a favorable spot in the stream, and fastens the edges down close to the water. A flap is left so that one can enter each morning and gather the insects that have issued during the night. Mr. Roberts has shown that one may gather many rare aquatic insects from a stream by stretching a net across it and disturbing the pebbles and stones above the net. The loosened insects will float down-stream against the net.

Most of the aquatic insects can be carried home alive, wrapped in wet waterweeds. Sometimes one can find insects transforming; these may be collected and carried home in paper bags, where, in a day or two, they will attain full development. In this collecting one should be careful to save the moulted skins. By closely observing one particular stream or pond one can often connect the insects with their larvæ without the necessity of rearing them.

INSECT BOXES AND CABINETS.

Insects should be kept in a tight, dry, and dark place; tight to exclude insect pests; dry to prevent mold; and dark to preserve the colors. Light will gradually fade the colors, so that if glass-top

boxes are used they should be placed in a dark cabinet. There are two styles of insect boxes, the small box about 10 by 12 inches with a hinged cover, and the drawers about 18 by 20 inches, with a removable cover and which slide into a case or cabinet. The small boxes are usually stood up on one of the long edges. The drawers are by far preferable for most insects, and are especially useful in museums, or for large and valuable collections. Beginners sometimes use empty cigar boxes, lined with pith or cork. These, however, are not tight, and should be used only for temporary storage of recently collected specimens. Pasteboard boxes, if kept in a well-dried place, are useful for beginners, and may be purchased cheaply from the dealers in insect supplies. The small folding boxes, about 10 by 12 inches, are used by a great many entomologists.

There are several makes of these boxes, the best being the Schmitt box (fig. 164), which has the top and bottom of two thin pieces cross-grained so as to prevent warping. The top fits down tightly over a raised ledge of the lower part. They are best made of well-seasoned pine, white wood, or linden. The Schmitt box is usually 8½ by 13 inches, but a size 12 by 15 inches is also for sale. The bottom is lined with pressed cork, or, what is better, patent cork. Sheet cork is still better, if one can afford to buy the best quality. Most of the dealers also make a cheaper box similar to the Schmitt box, but without a double top and bottom. A metal case is now manufactured for holding Schmitt boxes in a horizontal position. Each metal case holds two rows of fourteen boxes, and is provided with a clasped cover, which keeps out the dust, as well as pests. The drawers are made of various sizes—18 by 23 inches is often used for Lepidoptera; others use 16 by 20 inches. These commonly have a glass top and fit into a glass case or cabinet, holding sixteen to twenty, which is better if closed by doors. These drawers often have a hardwood front, and the cabinets are sometimes expensively made so as to be an ornamental piece of furniture.

The U. S. National Museum uses a drawer 18 inches square and 2½ inches deep (figs. 165, 166). The box has an inside partition inclosing a space about one-fourth inch wide all around, which is filled with flake naphthalene to form a poison chamber (*d*). The sides are of mahogany and the bottom is of three-ply, cross-grained veneer, and is covered with patent cork (*b*) and lined with white paper. The cover is of glass, fitting into a flat frame three-fourths inch wide with a one-fourth inch tongue, which fits into the space between the inner and outer boxes. A groove (*g*) is made in the sides of the drawers, upon which they slide on a strip in the cabinet. The cabinets now being used are of metal, a double tier, the lower box of thirteen the upper of twelve

drawers. These cabinets have a removable metal cover. Formerly the drawers were 3 inches deep and fitted into double wooden cabinets, holding twenty drawers and closed by paneled folding doors. These drawers can be made more cheaply if of some other wood, as pine or white wood. It is well to have a small label holder

FIG. 164.—THE SCHMITT FOLDING INSECT BOX, OPENED AND SHOWING ARRANGEMENT OF INSECTS.

attached to the end of the box, or front of the drawer. Formerly double boxes, or book boxes, were very popular with some collectors, two boxes of about 10 by 12 inches hinged together, one serving as the top of the other, and each of the same depth, so that insects may be pinned in each box. They are stood up on ends and the backs covered to resemble books.

The Museum of Comparative Zoology keeps its insects in drawers 15 by 18 inches, inside measurement. The drawers are in double cabinets with hinged doors, holding nine drawers each. No cork is used in the bottom, which is made of soft wood, so that a pin may

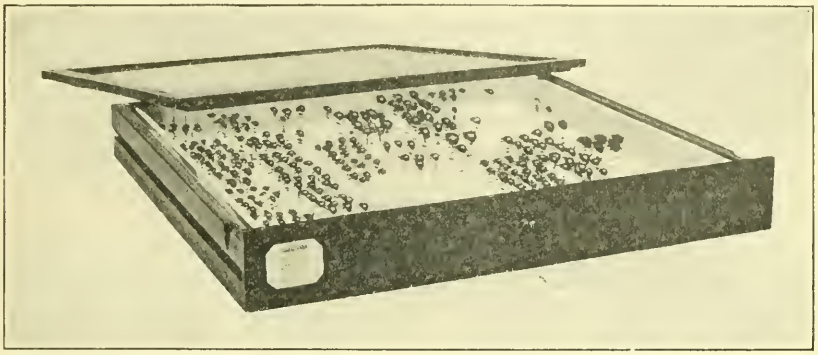

FIG. 165.—THE U. S. NATIONAL MUSEUM DRAWER, SHOWING ARRANGEMENT OF SPECIMENS.

be inserted into it. The tops are of glass, and the frame has a groove which fits very tightly over a tongue from below. The tops are held down closely by hooks and eyes. Professor Comstock uses a drawer with glass bottom as well as top. A number of small flat

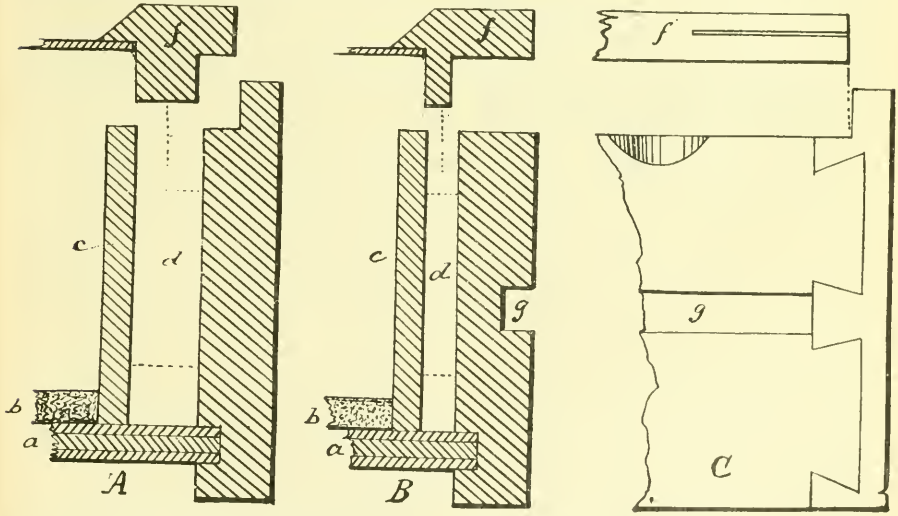

FIG. 166.—CONSTRUCTION OF THE INSECT CABINET DRAWER OF THE U. S. NATIONAL MUSEUM: A, CROSS-SECTION OF FRONT; B, SAME OF SIDE; C, VIEW OF FRONT END OF SIDE, TWO-THIRDS NATURAL SIZE. *a*, BOTTOM; *b*, CORK LINING; *c*, INSIDE STRIP FORMING NAPHTHALENE POISON CHAMBER; *d*, NAPHTHALENE POISON CHAMBER; *f*, TOP; *g*, GROOVE.

blocks, arranged in rows, cover the bottom. The cork is fastened to each block. One species or genus can be pinned on each block and the block transferred to a different part of the box, if desired, without handling the specimens.

The Carnegie Museum uses a drawer 16 by 22 inches and 2 inches deep inside. The top is of glass. The sides have a pocket on the inner edge. The paper over this pocket is perforated with small holes. Naphthalene crystals are placed in the pocket and the fumes reach the interior of the box. Mr. Martindale had his Lepidoptera in drawers with glass bottom and top. Across the bottom were narrow strips of cork, supported in narrow tin frames. The specimens are pinned into this cork strip, and by turning the box upside down, one can see the underside of the insect. For large insects only four or five strips were used in each box; for smaller forms ten or twelve strips. Each strip was fastened at its upturned edge by a thumb tack to the end of the box.

The Deyrolle drawers used by some entomologists are light boxes about 15 by 18 inches, with a narrow strip of zinc set edgewise all around the top of the lower part of the box. The cover is glass, and the frame of cover has a narrow groove to fit over the strip of zinc. They are very tight, and for some insects too tight, as one has to lift up the top very gradually else the suction will break the wings of frail specimens. These Deyrolle drawers are lined with either pith or cork.

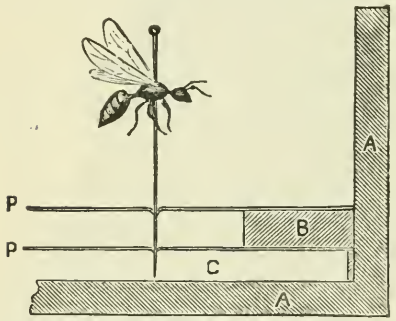

FIG. 167.—PAPER LINING FOR INSECT BOX: *A*, *A*, SIDE AND BOTTOM OF BOX; *B*, FRAME; *C*, OPEN SPACE; *P*, *P*, PAPER. (AFTER MORSE.)

Various substitutes have been used for cork. The compressed cork is usually of uneven texture; patent cork is a much better material. Many have used sheets of peat covered with paper, which is very soft, and for study collections it is handy, but is apt to produce too much dust. It is cheaper than cork. Pith of various plants has been recommenced. Corn pith can be readily obtained and if well dried can be used by the beginner for lining cheap boxes. A material called "Suberit" is being used by many collectors. Corrugated paper can also be used for temporary boxes. A substitute for cork is a soft thick paper, drawing or log paper, stretched on a frame that fits in the bottom of the box. If the paper is moistened slightly before being glued to the frame it will tighten in drying. Paper may be glued to both sides of the frame as in figure 167. The frame rests on a one-fourth inch ledge, leaving a little space between it and the bottom of the box.

Special mounts of insects.—The Denton brothers have invented a way of mounting insects known as Denton tablets. These are blocks of plaster of Paris with a depression for the body of the insect, and glass covers. The glass cover is hermetically sealed to the block

by paper strips. These tablets can be purchased for a moderate price. What are known as Riker mounts are used to exhibit insects. There are pasteboard boxes, having tightly fitting covers with a glass top. The box is lightly filled with white cotton, the insect spread out on top of it, and the glass cover put down and fastened (pinned) or sealed with gummed paper. These boxes are made in various sizes, and can be procured from the dealers. They are not pest-proof, but insects may be kept a long time in them without any trouble. Flake naphthalene may be scattered in the lower layers of cotton to keep out pests.

ARRANGEMENT OF INSECTS.

Within the boxes or drawers insects are customarily arranged in vertical columns, the larger species in three or four rows, the smaller species in from six to eight rows. It is generally possible to adopt a uniform width for the insects of each family; four columns in a Schmitt box and six in a drawer are the usual number. Many entomologists make no marks to indicate the edge of the column; some use strips of colored paper; others make a pencil or ink mark; and Doctor Britton has suggested the use of a fine wire, bent down at each end. The specimens should be carefully pinned in to preserve the alignment of each row. Some prefer to arrange the specimens beginning with the larger ones and ending with the small forms; others put them in alphabetically; but the best way is to follow a catalogue or published list. Formerly four specimens were considered a "set" of the species; now, most collectors wish eight specimens, and collections in the museums usually run up to twenty-five or more. A large series enables one to present the variations and range of the species. Museums sometimes make a duplicate collection of the overflow from the regular series. It is desirable to leave some vacant space in each box for additional species. Where the sexes are separated, the males are kept in the first row and the females behind them. Each species in the collection should, if possible, be labeled with its generic and specific name. Some prefer to pin the label to the first specimen of each species, and this is suitable for most collections. Many entomologists prefer to have a small label with specific name pinned behind the series of each species and a larger label with the generic name in front of the first species of the genus. Others include also order, family, subfamily, and tribe labels, but an overlabeled collection detracts from the specimens. Blank labels are for sale by all dealers. One should not use a label larger than necessary to write legibly the name of the insect. Museums sometimes purchase two copies of the various catalogues and cut them up, fastening with short pins these printed labels behind each species.

Some collectors arrange valuable specimens, such as types of new species, differently from the regular collection. Mr. Ball and others keep the type-specimens in separate boxes, taking care to handle them as little as possible. Mr. Caudell puts up types of Orthoptera in Riker mounts, but this will hardly do for insects of any other order. Many entomologists send their types to some large museum. Several entomologists, who have sufficient means for the purpose, construct a small building of brick or stone to house their valuable collections.

PESTS IN COLLECTIONS.

After the entomologist has collected, pinned, spread, labeled, and arranged the specimens in the cabinet he is not permitted to keep them in peace. Certain other insects, mites, mold, grease, etc., make their appearance, and unfailing vigilance is the price of perfect specimens. Neglect to attend to a collection will surely invite its destruction. In some parts of the country these pests are not nearly as abundant or as destructive as in other portions. The most injurious insect pests are beetles of the families Dermestidæ, Bostrychidæ, Ptinidæ, and Tenebrionidæ.

The larvæ of the Dermestidæ are hairy creatures with short legs and often with tufts of hair at the ends of the body. They feed and breed all the year, except when it is too cold. They will feed on a great variety of substances, boring into and reducing them to a mass of fine dust. The forms most injurious belong to the genera *Dermestes*, *Trogoderma*, *Anthrenus*, *Attagenus*, and *Perimegatoma*. *Anthrenus verbasci* (*varius*) is the common pest in most collections in the northeastern part of the United States. *Trogoderma tarsale* is more abundant in the South and West. *Anthrenus scrophulariæ* is occasionally found in collections. Two species of *Attagenus*, *A. pellio*, and *A. megatoma*, sometimes attack insect collections, and *Dermestes lardarius* is also an occasional enemy. *Perimegatoma variegatum* is so far only found in collections in California. Recently a peculiar and remarkable dermestid has been found in some collections; it is *Thelydrias contractus*, better known as *Ignotus ænigmaticus*. The Chilean insect pest *Cryptorhopalum flavopictum* will doubtless some day be introduced into our collections. Of the Ptinidæ, one species, *Ptinus fur*, is sometimes found feeding in collections, and one Tenebrionid, *Tribolium ferrugineum*, a cosmopolitan beetle feeding on many kinds of stored foods, is found but rarely, most often on imported collections. One Bostrychid, *Dinoderus pusillus*, has been also taken a few times in insect collections. Of the Psocidæ, several species of wingless forms, principally *Troctes divinatorius*, often do much damage to pinned insects. The delicate specimens are especially subject to their attack. A few mites and a Tineid larva are

sometimes injurious to dried insects. When in the field, ants sometimes get into the collecting box. If the box be soaked in oil of tar, the odor, which keeps for many years, will prevent the entrance of ants. In the South, ants of the genus *Monomorium* sometimes attack collections, getting into Schmitt boxes through the crack near the hinges.

Remedies.—Insects will get in where one would hardly suppose it possible, so that the collector should be extremely particular as to the tightness of boxes. There are two excellent methods of fighting insect enemies of insect collections. One is the use of carbon bisulphide to fumigate the boxes. A little poured into an infested box will destroy all living insects. A good plan is to put the open box into a larger box in which is placed a little of the carbon bisulphide. In this way one will not stain the paper of the insect box. Museums often have a large box especially prepared for fumigating specimens. A good way is to fumigate all specimens received before placing them in the cabinet. Carbon bisulphide is highly explosive, and should not be used near a light.

FIG. 168.—A NAPHTHALENE CONE.

The best repellent against insect attack is naphthalene. A good quality will not only keep out the insects, but will hinder the development of their larvæ and eggs. The best form in which to use this material is that of the crystals, known as "flake naphthalene." The dealers supply cones of naphthalene (fig. 168), with a pin, which may be fastened in the corners of the box. It is easy, however, to make these for oneself by utilizing the common moth balls. A heated pin is thrust head-first into a moth ball. As it cools it is fastened solidly into the ball. The cones and moth balls in evaporating leave a dirty, blackish deposit. One may prevent this from soiling the paper of the box by pushing a small paper pill box up the pin under the cone before pinning the cone into the box. Another way is to wrap the moth ball in a bit of Swiss netting and pin this in the corner of the box. Some collectors use creosote to kill pests. A wad of cotton soaked in creosote is placed in a small metal box or thimble, which is fastened or pinned in the corner of the box. The English often use carbolic acid and sometimes oil of lavender for protecting their collections. A piece of camphor is dissolved in the carbolic acid, and then this is poured on a small sponge which is pinned to the cover of the box.

Mold.—If a collection is stored in a damp place, or if pasteboard boxes are used in a moist climate, the specimens are apt to mold. Carbolic acid is the best remedy. A little poured into a box, or, better, on a sponge pinned in a pill box in the corner, will prevent mold. Moldy specimens can be cleaned with carbolic acid applied with a fine camel's-hair brush.

Verdigris.—The acid juices in the bodies of certain insects have an affinity for pin metal, so that when these specimens are mounted on bright pins a green substance known as verdigris will accumulate about the pin, finally corroding it so that it will easily break. Black or japanned and silvered pins do not verdigris, and therefore are to be preferred for many insects. In collections there are often specimens which have been pinned with a white pin and later have verdigrised. If it is desired to save these they should be remounted with black pins. This may be done by putting the insect for a day or two into the relaxing jar; then pull out the pin and place the insect in ether or gasoline, which will dissolve the grease and verdigris; then clean and put in a new pin. It is claimed by some that ammonia will dissolve and remove the verdigris. Aquatic insects and those whose larvæ live in wood are particularly subject to verdigris. Insects saturated with salt water are also apt to corrode the common bright pins.

Grease.—Some insects have so much fat in their bodies or it is in such a condition that in drying it spreads over the insect and out on the wings. This is a common trouble with many moths. They can be readily cleaned with gasoline or ether. Pin the specimen tightly to a piece of cork which is fastened in a deep vessel, then fill up the vessel slowly and carefully with gasoline until the specimen is covered. It may be left for two or three days, and when taken out and dried in a place where there is no dust it will become as fresh and clean as a perfect specimen. If only the abdomen is greasy this may be broken off and put into the gasoline, and later glued to the thorax. Sometimes it will be necessary to keep badly greased specimens in the ether or gasoline a longer time, or to change to fresh gasoline at the end of two or three days.

The Denton brothers put papered Lepidoptera, papers and all, into the gasoline and leave for two weeks; then take out and dry, without removing the insects from the papers. When dry they are fluffy and fresh as though never wet. Of course gasoline should not be used when near a light. Collections of insects should be looked over twice a year for pests, at least in a region where pests are at all common. The dates will vary somewhat according to latitude, but the best times will be in March or April in the spring, and again late in August or early September. No one who really loves the specimens he has collected and studied will fail to take proper care of them.

REARING INSECTS.

It has already been indicated that the best way to secure perfect specimens of Lepidoptera is by rearing them from the immature stages. Many entomologists, however, soon become interested in the life histories of insects, and find the collecting and rearing of the

larvæ as attractive as even the study of the minute details of structure in the adult insect. In no branch of natural history are life histories more readily studied than in insects. The ease with which the caterpillars of many butterflies and moths may be kept in captivity make them the most suitable subjects for experimentation in many lines of biological inquiry. As in collecting so in rearing, the simplest apparatus is usually the best. However, different groups respond better to different treatment, and there are many wrinkles in the handling of living material that can only be obtained by long practice.

For many caterpillars almost any sort of a wooden box, with some sand in the bottom and covered with mosquito netting, will make a suitable rearing cage. Branches of the food plant can be put in each day, the moist sand keeping it fresh until the next day. Tight boxes may be used, provided they are kept clean. For small insects glass jars or jelly glasses are very useful, and many species can be reared in ordinary glass test tubes, plugging the top with a bit of cotton. A pot cage is readily made by taking a flower pot with soil in which there is inserted the plant, and over the plant an ordinary lamp chimney, pressing it down well into the soil and covering the top with netting. (See fig. 169.) By pouring water into the saucer of the flowerpot the plant may be kept moist. Mr. Foster has modified the plan slightly by using a tin can of earth containing a bottle of water in the center, the top of the bottle even with the top of the soil. The plant or branch is placed in the bottle and about its base a wad of cotton, so the larva can not fall into the water. Over the plant is placed a glass Welsbach gas chimney covered with netting.

FIG. 169.—A LAMP CHIMNEY CAGE.

A more elaborate breeding cage utilized by Doctor Riley is shown in the illustration (fig. 170). The box is of wood, with a removable top covered with wire netting. The sides are of glass, or may also be of wire netting. One side is made into a door. The cage can be placed on a zinc base made as in figure 171. This cage may be made any size. A convenient one is 12 inches square and 18 inches high. The inner box of the metal vase has holes in it so that water put in the outer box will moisten the sand in the inner box. The branch or plant may be put in the top "*d*" with a wad of cotton to hold it in place. Many species will breed in almost any situation, but with

others one must be particular about fresh food, sunlight, and ventilation. The amount of moisture necessary for the proper development and expansion of the wings varies, and one must learn this by experience. A wet sponge or blotting paper will give a supply of moisture. One should be careful not to put too much food in the cage at one time, as it may mold and injure the larva. Some larvæ feed better in a darkened place. This may be simulated by wrapping the jelly glass or other cage with a piece of black muslin. Other larvæ will feed only at night, and should have some soil or litter in the bottom of the box under which they may conceal themselves during the day. After once starting a larva on a certain food plant it is not well to change it, although it can sometimes be done with safety, and seems to be preferred by a few caterpillars.

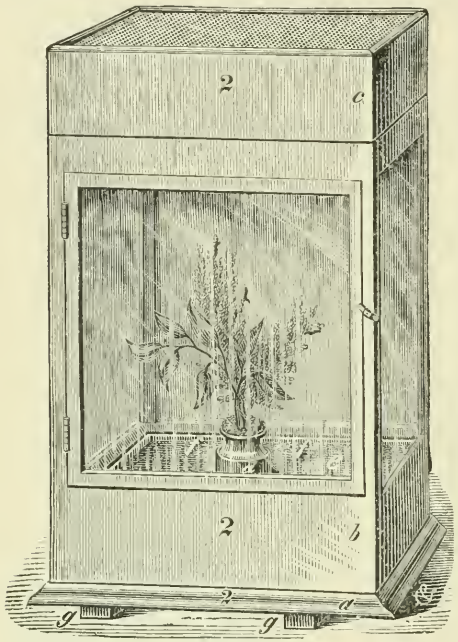

FIG. 170.—AN INSECT BREEDING-CAGE, OR VIVARIUM.

Sometimes it is impossible to obtain the ordinary food plants of the larvæ, and one must resort to a substitute food plant. Often an allied plant will give satisfactory results. If, for example, a larva

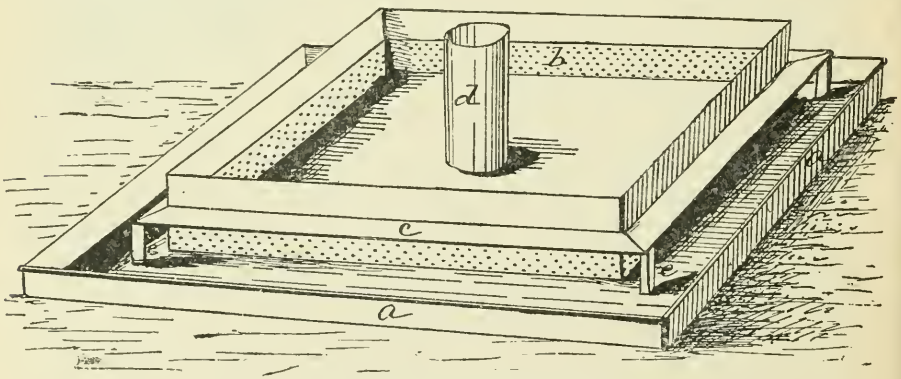

FIG. 171.—THE IMPROVED BASE FOR BREEDING-CAGE.

should feed on apple, and this can not be had, one may discover that an allied larva feeds on walnut, or both apple and walnut; then walnut may be the substitute for apple in the first case. There are a

number of plants that are eaten generally by a large number of caterpillars. Polygonum, for example, is noted as a food plant for many Geometridæ; lettuce is eaten by many Noctuidæ; apple by many Notodontidæ, etc. Buds are sometimes split and fed to larvæ that issue before the leaves are out.

In some cases it is better to put a cage over an outdoor plant. A headless keg covered with gauze makes a good outdoor cage. Two or three pieces of willow may be bent over a plant, the ends stuck in the ground, and this frame covered with gauze or netting. Moths and butterflies may sometimes be induced to oviposit in such a cage when they would not in the laboratory. Mr. Fletcher succeeded in getting a few eggs from reluctant females by gently pressing the tip of the abdomen until one or two eggs were deposited. This may be done with specimens that have just died. Outdoor cages are used by the cotton boll weevil investigators and at the gipsy moth laboratory. They are light frames covered with wire netting, and tall enough for a person to stand in them. Some styles are described in Technical Bulletin No. 12, part 6, Bureau of Entomology, U. S. Department of Agriculture. Others may be devised to suit special circumstances by any ingenious mind. One may find it advantageous to tie a piece of netting over a branch or twig on a tree or bush outdoors. This is especially useful in getting the insects that are developing within the seeds of plants.

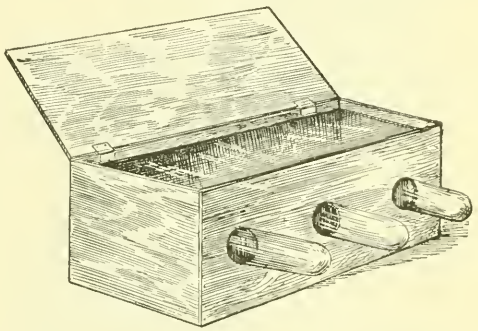

FIG. 172.—A BREEDING-CAGE FOR PARASITES.

A breeding cage (fig. 172) used by the California Board of Horticulture and by the cotton boll weevil investigators is a wooden box 10 or 12 inches long and 6 to 8 inches wide and of about the same depth. This box is fitted with an inner cover of glass and an outer cover of wood. One can therefore examine the material without permitting the escape of the insects. In one side of the cage several holes are bored and a glass tube fitted into each. The insects will be attracted by the light and come out into the tubes. The tubes can be quickly removed, the hole stopped with cotton, and the insects dumped into a cyanide bottle. For insects that pupate in the soil a layer of sand may be put into the bottom of this box.

Professor Comstock has devised a root cage, as shown in figure 173, in which to rear and study hypogean or underground insects. The cage consists of wooden ends with glass sides. It is filled with soil,

and the plants send their roots down near the glass. The glass sides are covered with a sheet of tin or zinc which excludes the light. This cage may be let down into a hole in the soil and so kept at about the normal temperature of the soil. A large number of wood-boring insects may be reared by collecting dying wood and fallen twigs in the autumn and carrying them into a room. In the spring the insects will issue and fly to the window. Similarly galls, acorns, and seeds of various kinds may be placed in jars to rear the insects.

Mr. Elliott, who raised many pupæ, kept them in a pupa box made as follows: A box about 20 by 16, and 8 inches deep, with a bottom of coarse wire cloth placed about 2 inches from the bottom, is divided into four compartments by thin wooden partitions. Over the wire cloth is placed a thick layer of baked sphagnum moss which has been

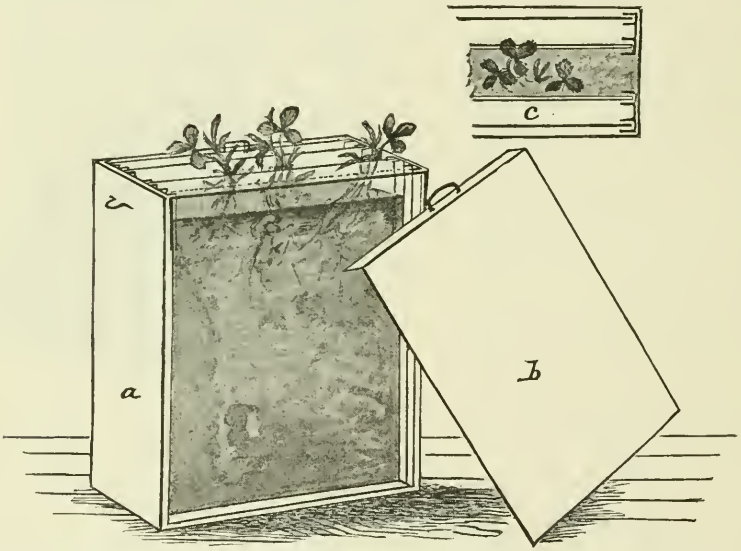

FIG. 173.—A ROOT CAGE, FOR REARING INSECTS WHICH LIVE UNDERGROUND. *a*, FRAME WITH SLIDE REMOVED; *b*, MOVABLE SLIDE; *c*, TOP VIEW.

pulled into fine bits. The pupæ are laid on this floor of moss and covered with a thick layer of moss prepared in the same manner as that beneath. The box is covered by a glass plate. In the summer and autumn this box may be kept over a pan of water, but in the winter time it should be left in a cool room or even out of doors where it will not be injured nor become too wet. Pupæ should not be kept in a heated room. They are apt to dry out or else the imago will not properly expand its wings.

Mr. Burke made a neat cage for rearing some insects infesting bark by knocking off the bottom of a baking-powder can, cutting the sides into narrow strips, and tacking these to the tree over the spot where the insect was feeding. This cage is shown in figure 174.

It is very instructive to keep ants in an artificial nest. A simple one may be made by taking a piece of 1½-inch board, say 12 inches square, and make near the edge a channel three-fourths inch deep and 1 inch wide, and put in the center two panes of glass 8 inches square, and between them a thin layer of soil or comminuted wood. Cover the top glass with a piece of tin. The channels around the edge of the bottom board should be nearly filled with water. Ants placed between the glass will excavate tunnels, and may be kept a long while. A better nest (fig. 175) for studying the habits of ants was prepared by Miss Fielde, and is as follows: It is made of panes of glass glued together by Le Page's liquid glue. A large square pane is used for the bottom. The wall and partitions are narrow strips of glass laid flat. Two strips of "double thick" glass make it the right height. An aperture at "*a*" is left, but plugged up with cotton except when one wishes to transfer the ants to another nest. On the top of each wall and partition is a narrow strip of coarse toweling. It is glued to the top of the glass and then the free edge turned back. The partitions and walls are then less than one-half inch high. Two panes of glass are

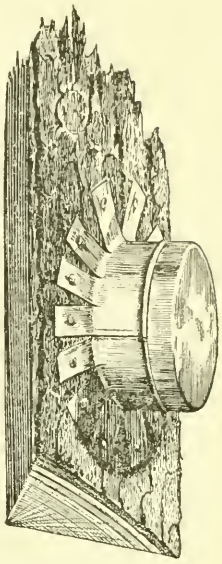

FIG. 174.—A CAGE FOR REARING BARK-INFESTING INSECTS, FASTENED TO TREE.

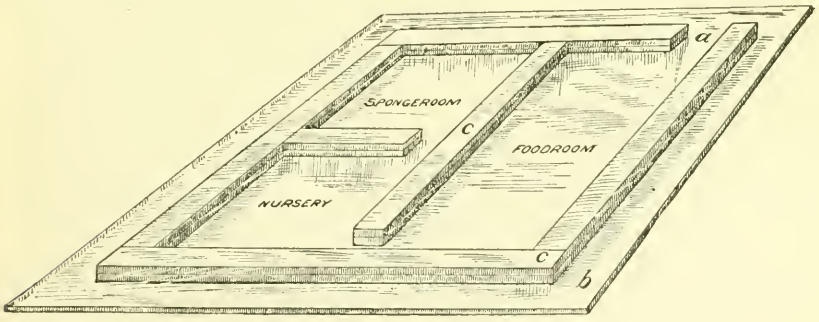

FIG. 175.—THE FIELDE ANT NEST: *a*, *b*, GLASS BASE; *c*, *c*, PARTITIONS.

used for the roof, so that one can be removed at a time. These roof panes are just laid on and not fastened. Over each is a piece of black blotting paper to darken the rooms. The outside walls are also painted black. In one room is a thin, flat piece of wet sponge; this is to furnish drink for the ants and moisture for the rooms. If the ants have many cocoons, a piece of dry cloth should replace the sponge, as ants keep their pupæ in dry situations, while the larvæ need moisture. The whole nest can be placed on a sheet of white blotting

paper. Food is placed in one room. The other room is kept for the nursery. More elaborate nests can be made on this same plan, with more rooms and with some slender partitions near the larger walls to simulate ant runways. The roof may be fastened down and the nest carried about, or several nests may be fitted into a case especially made to carry them.

Doctor Barth has kept ants in artificial nests made by placing a glass jar or cylinder inside another glass jar of slightly greater diameter, the space between the two filled with soil, or wood dust, in which the ants can tunnel and form their nests. The inner jar is shorter than the outer, and the inner space or well is used as a food chamber. A stick leading from the bottom of the well to the top of the inner jar permits the ants to go from the nest to well and back. A net of wire can be placed over the top of the outer jar to prevent the escape of the ants. A cylinder of dark paper can be slipped over the outer jar to darken the ant burrows.

To rear the predaceous beetles, like *Cychrus* and *Carabus*, one should place them in wooden boxes with fine-mesh wire covering. In the bottom of the box put about 2 inches of earth, moss, and decayed wood. On the top of this sprinkle the ground with water every two days. The *Cychrus* feeds on snails. Other forms will eat meat, or the maggots on fly-blown meat. When eggs are observed in the cage, remove the beetles and keep the cage in a dark, cool place. When the larvæ are a few days old, each should be kept in a separate box. The principal enemies of breeding insects are mold and mites. The mold must be prevented by using no more moisture than necessary and by ventilation. The mites, often of the genus *Pediculoides*, are kept out by thorough cleanliness and washing the cages and jars in a solution of carbolic acid and later in hot water.

Rearing aquatic insects is often more difficult than rearing terrestrial species. In some cases one can take a large Mason fruit jar, or purchase a glass jar from the dealers, and put some sand and pebbles in the bottom, and with a few fresh-water plants he can keep a number of species for some time. The main difficulty is in the water becoming stale. All decaying matter and uneaten food should be removed with a pipette or long glass tube. It does not pay to try to keep too many kinds of insects in the same aquarium. Some of the dealers sell flattened jars, 2 or 3 inches thick and 6 or 8 inches wide, and a foot or more high, which are very suitable for aquaria. Any large predaceous species will, of course, soon free an aquarium of its other inhabitants. Where one has a flow of water available, he can arrange a siphon outlet and insure fresh water all the time. Many aquatic larvæ will not develop properly unless in running water. If near a stream, one can arrange a cage of wire screening

or Swiss netting over a stone or plant in the water on which are the larvæ of the desired insects.

Doctor Needham has used for rearing aquatic insects a wire cage shown in figure 176. It is a cylinder of galvanized wire screen, open at both ends, with a loose screen cover. The cylinder may be pushed down over the plant or rock deeply enough into the bottom so that the larvæ or nymphs can not escape, sometimes 2 or 3 inches into the mud.

A water cage or aquarium can be made by cementing together panes of glass. Make a bottom of one piece of wood, with a groove around the edge. Set the panes of glass in the groove and bind their edges where they come together with strips of muslin glued on the outside, and place a narrow, oblong strip of glass inside across each corner. Fill this space and also the bottom groove with a cement made as follows: White sand, 1 part; plaster of Paris, 1 part; litharge, 1 part; and powdered resin, one-third part. Make into a thick paste with boiled linseed oil. Let the cement harden for several days before putting the water into the aquarium.

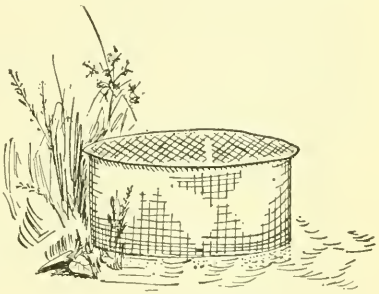

FIG. 176.—THE NEEDHAM AQUATIC CAGE.

In rearing mosquitoes it has been found necessary to isolate the larvæ. Doctor Dyar does this as follows: When a batch of larvæ is gathered in a vessel from a pool a number of flat-bottom vials (8-dram) are half filled with water from the same pool and a little dirt or mud from the bottom of the pool placed in the bottom of each vial. Then with a pipette each larva is transferred to a vial, one larvæ only in each vial, and the top plugged with cotton. When the larva changes to a pupa the last larval skin is removed and put into a tiny vial of alcohol with a little glycerin. This vial is then inserted in the cotton, plugging the larger vial until the mosquito emerges from the pupa. Then both mosquito and larval skin are given the same number. One is thereby certain that the skin and adult are of the same species. The adult mosquito should not be killed as soon as it issues, but allowed a day or so to chitinize and attain its colors. The vials with larval skins may be stored or canned in larger bottles until one desires to study them, when they should be mounted on slides. Anopheles mosquitoes need more surface than is afforded by a small vial and can be reared in open saucers.

In rearing caddiceflies, Vorhies has found that for those that inhabit standing waters ordinary crystallization dishes, 6 or 8 inches

in diameter, provided with a screen cover, are suitable receptacles. Whenever possible one should try to obtain the pupæ, as results are more certain, and in several families the larval exuvia is retained in the pupal case, and can be compared with larvæ collected at the same place. With other species occurring in running water it will be necessary to supply them with running water, or else to place a small cage over a larva in a stream and await its development.

SHIPPING INSECTS.

Entomologists increase their collections largely by exchange. A collector in one part of the country writing to one in another tells him what he wants and what he has to offer in exchange. These lists are called "desiderata" and "offerta." Sometimes, in exchanging, collectors use the numbers of some recognized catalogue instead of writing out the names. It is customary in sending to number the specimens and in the letter give the list of numbers with the names. In exchanging, one should endeavor to send as good specimens as possible, neatly mounted and labeled and carefully packed in secure boxes. Most insects are fragile, and one must use great care in packing them. The specimens should be securely pinned in the box, but not hammered down. If there are any with large bodies or long, slender abdomens, these parts should be braced by pins placed crosswise. The top of the box should be so fastened that it can not be easily mashed in. A strip of wood is sometimes fastened on the inside at the top of the box to give further support to the cover. The box should, if sent by mail, be wrapped, not too tightly, in cotton or excelsior about 1 inch thick around it. However, it is better to put this box into a larger box, with 1 inch space or more each side, and this is filled, but not too tightly, with cotton or excelsior.

Sometimes a little cotton is placed around the outside of the outer box. Most Coleoptera, Hemiptera, and Hymenoptera are not very fragile, and a good wrapping of cotton or excelsior is all that is necessary. With Lepidoptera, Neuroptera, and Diptera one can not be too particular in packing. The Lepidoptera and Neuroptera are more safely shipped in papers in a tin or wooden box; then there is no danger of breakage.

If one has a box of specimens as large as an ordinary cigar box it had better be sent by express, especially if it contains fragile insects. There should be at least 2 or 3 inches space between the cigar box and the outer box; the latter should be a stout one and the space lightly filled with excelsior; never try to cram in all the excelsior you can, but only enough to keep the box securely in its place. It is much better to screw the top on than to nail it, as the jar in nailing may break or loosen something. The handiest way to ship by express is to use a flat half-bushel basket, packing it with excel-

sior and covering the top with stiff manila paper. The basket can be tied across each end, lengthwise through the middle, and then around the sides. The handle should be left on, and the address, as well as the name of the sender, written plainly on the cover, and the word "care," in large letters, will do no harm. In sending insects abroad by mail the package should be registered; if by express, use a box with cover tied with plenty of strong twine, so that the custom officers can examine without hammering or breaking the cover. Some use a glass-top box for the inside box. In sending by mail, never pack a small box on top of a larger one; it will break in the larger box.

In shipping alcoholic material, one vial may be placed in a wooden or pasteboard mailing tube (fig. 177) manufactured for such purposes. These are often lined with cork and have a screw top. The cotton packing around the vial should not be crowded in too tightly. When many vials are to be sent, each should be wrapped in a bit of soft paper and then all packed in cotton in a stout wooden or tin box; some cotton wrapped outside these boxes will prevent breakage. A bit of cotton placed in the vial with specimens will wad up and shake back and forth in traveling, and so destroy fragile specimens.

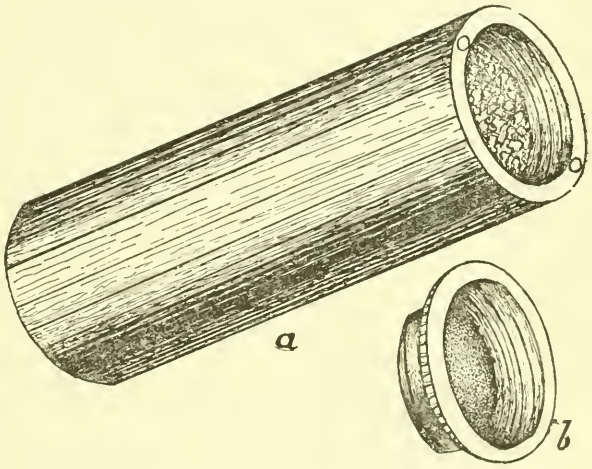

FIG. 177.—A MAILING-TUBE: *a*, TUBE; *b*, COVER.

Never send insects in a letter; it can be done over and over again, but it is risking the specimens. In sending living specimens use a tight box and do not punch holes in it; the insect will not suffocate. Sometimes it is necessary to put food in with the living insect, as a caterpillar sent for a considerable distance, but usually anything inserted with the specimens will simply help to kill them. The pupæ may be shipped in dry moss. Postal regulations affecting natural-history specimens vary from time to time; usually such specimens are sent as fourth class, 1 cent an ounce. Many foreign countries have a parcels-post regulation, which enables one to send large packages cheaply. When shipping papered specimens a long distance, a little flaked naphthalene sprinkled over them, or, better, in the packing, may

help to keep out insect enemies; if for a long sea journey, a little carbolic acid poured on the outside of the box will prevent mold. It should be remembered that insects imported from abroad are subject to customs duty of 10 per cent on unmounted and 20 per cent on mounted specimens.

Many of the leading entomologists in the United States are willing to name specimens sent to them for that purpose, provided, of course, they are permitted to keep any specimens that are new to their collection. Most of these specialists do this work in their leisure moments, and the sender should, therefore, do all he can to lighten the labor of identification. The specimens should be sorted in groups in the boxes as far as possible, and each specimen or each species should have a number. In sending Lepidoptera or other insects with large spread of wings they may be "shingled," that is, the specimens may be pinned obliquely backward, so that the wings overlap the specimens in front and to the side. This saves much space. Many collectors put a thin layer of cotton over the cork of a shipping box; this sometimes saves legs and abdomens.

COLLECTING ARACHNIDA AND MYRIOPODA.

Spiders (fig. 178), mites, thousand-legs, etc., are not insects, but belong to several related groups. The spiders and mites are Arachnida, distinguished by having eight legs and only two parts to the body—the front part, known as the cephalothorax and bearing the legs, and the hind part, called the abdomen. The true spiders, or Araneida, have no segmentation to the abdomen, which is attached to the cephalothorax by a slender pedicel. This cephalothorax in front has eight simple eyes, and below in front is a pair of stout jaws, mandibles or cheliceræ. The palpi are short, leglike appendages near the mandibles. At the tip of the abdomen are four or six little processes, close together, the spinnerets. From these spinnerets issues the silken thread that spiders use to make their webs, cocoons, etc.

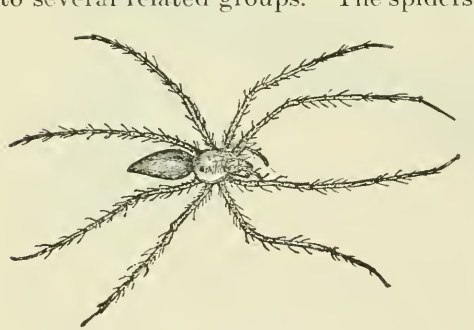

FIG. 178.—A SPIDER, PEUCETIA VIRIDANS. (AFTER COMSTOCK.)

The majority of spiders do not make a web, and live by hunting for their prey. The orb-weaving spiders (Epeiridæ) (fig. 179) make a geometrical or orb web, like spokes of a wheel, with cross threads; and there wait, head down, on the center of this web until some insect falls into it. The tarantulas (Theraphosidæ) are the largest spiders and have very hairy bodies and legs. Many of them live in holes,

mostly in the southern part of the United States. Sometimes they are found in the North in bunches of bananas.

The daddy-long-legs, harvest-men, or Phalangida (fig. 180) have the two parts of the body broadly joined together, so there is no pedicel. The abdomen shows the segments more or less closely united. The legs are longer than usual in spiders, and there are only two simple eyes situated on a little tubercle or eye-eminence on the front part of the cephalothorax. They have no spinnerets. The scorpions, or Scorpionida (fig. 181), have the body elongate, plainly segmented, and behind narrowed to form a tail or cauda, which ends in a vesicle with a sting. The abdomen is broadly united to the cephalothorax, and the palpi are long and end in two pairs of claws. There are two or three simple eyes on each side, and a pair in front on the cephalothorax. On the under side of the body, near the hind pair of legs, is a pair of appendages called "combs." The book or false-scorpions (pseudoscorpions) (Chelonethi) (fig. 182) are diminutive editions of the scorpions but without a tail. They have only one or two eyes on each side of the head and no "combs."

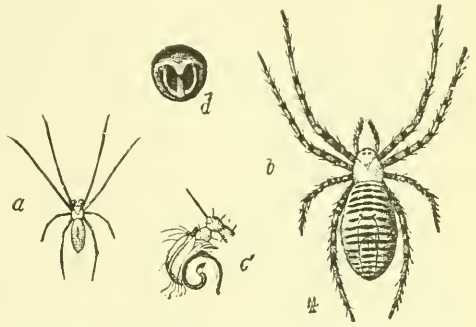

FIG. 179.—AN ORB-WEAVER, ARGIOPE TRIFASCIATA: *a*, MALE; *b*, FEMALE; *c* AND *d*, ENLARGED PARTS.

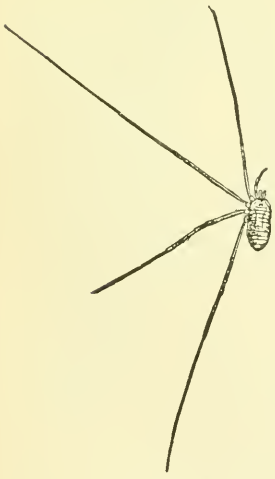

FIG. 180.—A HARVEST-MAN, LIOBUNUM VENTRICOSUM. (FROM PACKARD.)

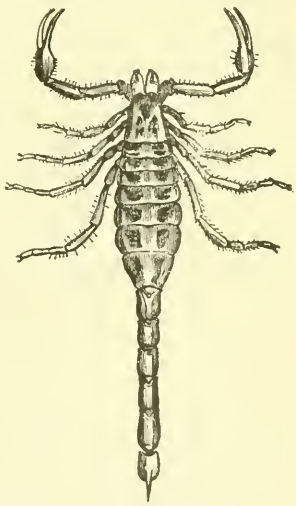

FIG. 181.—A TRUE SCORPION, CENTRURUS CAROLINIANUS. (FROM PACKARD.)

The mites and ticks, or Acarina, have no division of the body into parts or segments, or it is only faintly indicated. The mouth-parts are usually close together and form a beak or rostrum. They are nearly all of very small size and of very diverse shapes and habits.

Many are parasitic on man or other animals. The red spiders (Tetranychidæ) (fig. 183) are soft-bodied forms, feeding on the foliage of trees and plants, and they spin a thread wherever they go. The harvest mites (Trombidiidæ) are large, red mites sometimes seen wandering in the springtime. Their larvæ are called "red bugs," and attack people as well as animals. The cheese mites (Tyroglyphidæ) (fig. 184) feed on stored foods, cheese, flour, seeds, dried fruits, and the roots of plants. They are soft-bodied, and of a pale whitish color. The ticks (Ixodoidea) are larger than most mites, and with a tough, leathery skin. They have a breathing pore in a granulated plate just above the hind legs. The cattle tick (*Margaropus annulatus*) (fig. 185) is the carrier of Texas fever, and the Rocky Mountain tick (*Dermacentor venustus*) is the disseminator of spotted fever. The scab or itch mites (Sarcoptidæ) are small, soft-bodied forms that burrow in the skin of various animals, including man, thereby causing scabies, a disgusting disease. The Eriophyidæ, or gall-mites (fig. 186), are so small

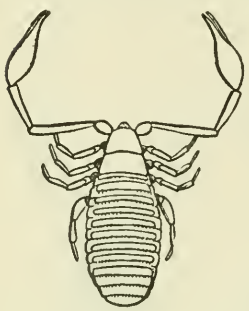

FIG. 182.—A FALSE SCORPION, CHELIFER CANCROIDES. (FROM PACKARD.)

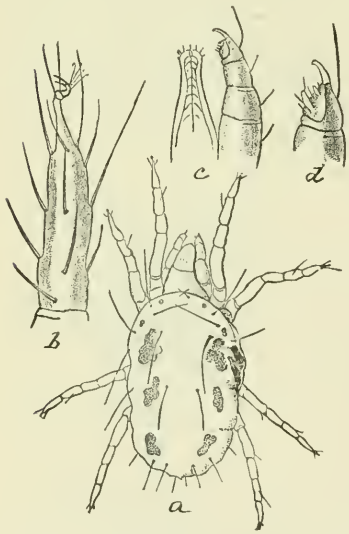

FIG. 183.—THE SIX-SPOTTED MITE OF THE ORANGE, TETRANYCHUS 6-MACULATUS: *a*, FROM ABOVE; *b*, TARSUS; *c*, ROSTRUM AND PALPUS; *d*, TIP OF PALPUS. *a*, GREATLY ENLARGED; *b*, *c*, MORE ENLARGED; *d*, STILL MORE ENLARGED.

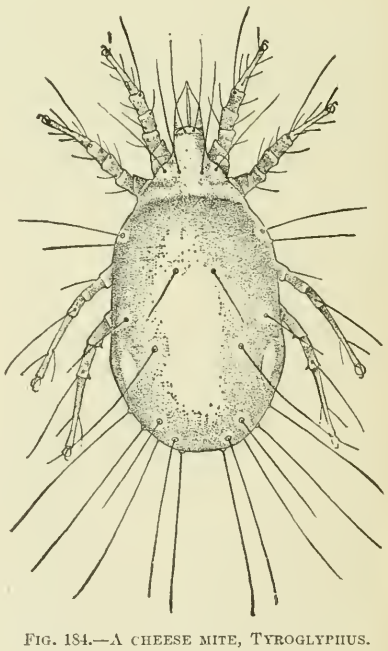

FIG. 184.—A CHEESE MITE, TYROGLYPHUS.

one can hardly see them without a glass. They make galls on the leaves of trees and shrubs. These galls have an opening which distinguishes them from most insect galls, excepting those of the Homoptera.

There are three other smaller groups of Arachnida. The Solpugidæ, or ringed spiders, sometimes called vinagarettes or vinagarones, have the abdomen segmented, the palpi are simple, and the mandibles are very large and prominent. The Phrynida are flat creatures with segmented abdomen connected to the cephalothorax by a slender pedicel. The palpi are spiny, and the first pair of legs very long and fine. The whip-tailed scorpions (Thelyphonida) have a segmented abdomen with a fine filament at the tip. Their palpi are very heavy and spiny. They are also called vinagarones and mule-killers, but are not poisonous. Most of the Arachnida are predaceous or parasitic on animals, but quite a number of mites are phytophagous. In most of our spiders the jaws are so small and weak that they can not pierce a person's skin, and those that can do so have not a poison sufficiently strong to cause much pain. The tarantulas of the West and South should not be handled, but the cases of dangerous bites from these creatures are extremely few. The ticks attach themselves to people, and sometimes their bite causes much pain, and one kind carries a disease. The red bugs, the young of harvest mites, are an intolerable nuisance in many parts of the South. The sting of our scorpions is rarely more severe than that of a wasp or hornet.

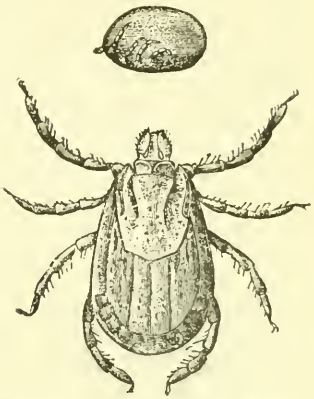

FIG. 185.—THE CATTLE TICK, MARGAROPUS ANNULATUS. (AFTER PACKARD.)

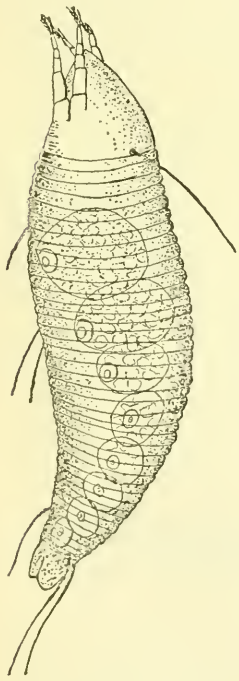

FIG. 186.—ONE OF THE GALL-MITES, ERIOPHYES.

The Myriopoda include two very distinct groups which really are not related to each other. One, the centipedes or Chilopoda, are like long wingless insects with a pair of legs to each segment of the body. The house centipede, *Scutigera* (*Cermatia*) *forceps* (fig. 187), is an example of this group. Its bite is often quite severe. Its poison comes from a large pair of jaws under the head, which is developed from the second pair of legs. They occur under leaves and stones,

or rotten wood, etc. The millipedes, or Diplopoda (fig. 188), are very remote from insects. They have a hard, round, or flattened body of many rings, and each ring bears two pairs of legs. Their mouth-parts are weak, and they feed on vegetation or decaying matter. None of them can bite.

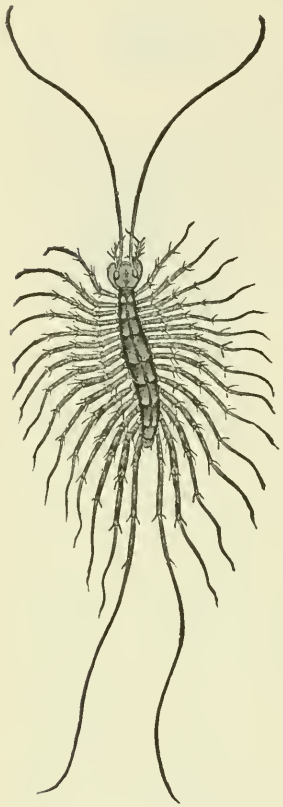

FIG. 187.—THE HOUSE CENTIPEDE, SCUTIGERA FORCEPS.

Most of the directions given for collecting insects apply to these groups. They are treated as alcoholic insects, but not so much apparatus is needed. A net is useful; a fine forceps is necessary, and a sieve net is very handy to get the small forms. All of these should be collected in vials of alcohol of about 60 per cent and later put in 75 or 80 per cent alcohol, with a little glycerin. The mites can be obtained by sifting leaves and moss, and under boards, in fungi, and on foliage. The egg sacs or cocoons of spiders can be collected in pill boxes. In collecting spiders one should learn to distinguish the adults from the young. The mature male has the tip of the palpi developed into a complicated accessory genital apparatus. The mature female has the vulva or genital opening exposed at the base of the venter of the abdomen. Spiders not having either of these two characters are immature. It is useful to collect the immature stages of spiders, but if one does not know the difference he is apt to gather a great number of young specimens. When one finds a spider in the young condition he may be able, by visiting the spot later, to find some adult specimens.

Most Arachnids and Myriopods should be kept in corked vials of alcohol with a little glycerine, just as alcoholic insects. Empty cigar boxes or Marx trays, made for a double row of vials, are suitable for arranging collections. The labels should always be inside of the bottles. Many mites are better when mounted in balsam or glycerin on slides. This is done as for mounting small insects. Many of these should be killed in hot water or acetic acid. The slides may be kept as those of insects.

FIG. 188.—A MILLIPEDE, CAMBALA ANNULATA.

COLLECTIONS OF INSECTS.

It will be of interest to the collector to know where some of the larger public collections of insects are kept. The principal public museums of the country containing important entomological collections are the U. S. National Museum, Washington, D. C.; the Museum of Comparative Zoology, Cambridge, Mass.; the Academy of Natural Sciences, Logan Square, Philadelphia, Pa.; the American Museum of Natural History, Central Park West, New York, N. Y.; the Carnegie Museum, Pittsburg, Pa.; the Museum of the Brooklyn Institute, Eastern Parkway, Brooklyn, N. Y.; the Field Museum of Natural History, Chicago, Ill.; the California Academy of Sciences, San Francisco, Cal.; the Boston Society of Natural History, Berkeley street, Boston, Mass.; and the Milwaukee Public Museum, Milwaukee, Wis. Besides these there are large collections in many of the universities and colleges, such as Cornell University, University of Kansas, University of Illinois, Rutgers College, New York State Museum at Albany, the Massachusetts Agricultural College, Ohio State University, University of Michigan, Colorado Agricultural College, University of Nebraska, Stanford University, University of California, etc. There is a directory of entomologists published by the American Entomological Society, Box 1577, Philadelphia, Pa.

PERIODICALS AND DEALERS.

The entomological periodicals of the country are as follows: Transactions of the American Entomological Society, American Entomological Society, Box 1577, Philadelphia, Pa.; Proceedings of the Entomological Society of Washington, Department of Agriculture, Washington, D. C.; the Canadian Entomologist, Entomological Society of Ontario, Guelph, Ontario, Canada; Psyche, Cambridge Entomological Club, Boston Society of Natural History, Berkeley street, Boston, Mass.; Entomological News, Academy of Natural Sciences, Logan Square, Philadelphia, Pa.; Journal of the New York Entomological Society, W. T. Davis, 46 Stuyvesant place, New Brighton, Staten Island, N. Y.; Annals of the Entomological Society of America, H. Osborn, Ohio State University, Columbus, Ohio; Journal of Economic Entomology, E. D. Sanderson, Durham, N. H. Many entomological papers are published in journals on general natural history and by the Bureau of Entomology, U. S. Department of Agriculture, and in the Proceedings of the U. S. National Museum.

The dealers in entomological supplies are: The Kny-Scheerer Company, 404 West Twenty-seventh street, New York, N. Y.; the American Entomological Company, 55 Stuyvesant avenue, Brooklyn, N. Y.; M. Abbott Frazer, 93 Sudbury street, Boston, Mass.; A. Smith

& Sons, 269 Pearl street, New York, N. Y.; Charles C. Riedy, 432 Montgomery street, San Francisco, Cal.; Bausch & Lomb Optical Company, 154 Sutter street, San Francisco, Cal.; Thiebaut Brothers (boxes), 2122–23, Lombard street, San Francisco, Cal.; the Simplex Net Company (nets), Ithaca, N. Y.; Queen & Co. (microscopes, lenses, etc.), 1010 Chestnut street, Philadelphia, Pa.; Bausch & Lomb Optical Co. (microscopes, lenses, etc.), Rochester, N. Y.; the Spencer Lens Company (microscopes, lenses, etc.), Buffalo, N. Y.; the Wiegner Printery (labels), 2234 North Twenty-ninth street, Philadelphia, Pa.; C. V. Blackburn (labels), 32 Chestnut street, Stoneham, Mass., and the Entomological Society of Ontario, Guelph, Canada.

OBTAINING AND KEEPING TRACK OF LITERATURE.

Although some of the books treating of insects can be purchased through the regular book trade, the larger number can only be secured through dealers in second-hand books. Many of these dealers advertise in the various entomological journals. Various societies frequently have for sale reprints of articles published in their proceedings. Such are the American Entomological Society, Philadelphia, the Entomological Society of Washington, the New York Entomological Society, etc. Some of these issue lists of the papers they have on sale. The various foreign dealers in second-hand books issue catalogues, which are sent free on request. It is cheaper to buy of these dealers directly than through an agency.

Owing to the great number of journals containing articles on entomology, it is often difficult to keep track of the literature on any particular subject. The Entomologische Litteraturblätter, published monthly by R. Friedländer & Sohn, Karlstrasse 11, Berlin, N. W. 6, Germany, at 25 cents a year, contains the titles of the greater number of articles published on insects. The Bulletin de la Société Entomologique de France and the Zeitschrift für Wissenschaftliche Insektenbiologie also contain lists of current literature. The Zoologischer Anzeiger publishes a nearly complete list of the literature on all zoology. The Zoological Record, published each year by the Zoological Society of London, contains practically all of the literature. The volumes are usually a year or more behindhand, and are rather expensive. The Concilium Bibliographicum at Zurich, Switzerland, issues references on cards. A list of works of value in studying North American insects is published by the Bureau of Entomology, U. S. Department of Agriculture, and can be obtained on request.

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